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# Work Plan for a Treatability Study in Support of the Intrinsic Remediation Option at PS-2

## Fairchild Air Force Base
## Spokane, Washington

**Prepared For**

## Air Force Center for Environmental Excellence
## Technology Transfer Division
## Brooks Air Force Base
## San Antonio, Texas

## and

## 92 CES/CEVR
## Fairchild Air Force Base
## Spokane, Washington

**September 1995**

**PARSONS ENGINEERING SCIENCE, INC.**

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# WORK PLAN FOR A TREATABILITY STUDY IN SUPPORT OF THE INTRINSIC REMEDIATION OPTION AT PS-2

for

AIR FORCE CENTER FOR ENVIRONMENTAL EXCELLENCE
TECHNOLOGY TRANSFER DIVISION
BROOKS AIR FORCE BASE
SAN ANTONIO, TEXAS

and

92 CES/CEVR
FAIRCHILD AIR FORCE BASE
SPOKANE, WASHINGTON

September 1995

by

Parsons Engineering Science, Inc.
1700 Broadway Suite 900
Denver, Colorado 80290

022/722450/FCWP/8.WW6

AQM01-01-0309

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# SECTION 1

# INTRODUCTION

This work plan, prepared by Parsons Engineering Science, Inc. (Parsons ES), formerly Engineering Science, Inc. (ES), presents the scope of work required for the collection of data necessary to conduct a treatability study (TS) for remediation of groundwater contaminated with petroleum hydrocarbons at the Flightline Operable Unit PS-2 (PS-2) located at Fairchild Air Force Base (AFB), 12 miles west of Spokane, Washington (the Base). Several groundwater remedial options will be evaluated as a part of the TS report, including: bioslurping; groundwater extraction, treatment, and disposal (i.e., pump and treat); biosparging; and natural contaminant attenuation (intrinsic remediation) with long-term monitoring. Hydrogeologic and groundwater chemical data necessary to evaluate the various remedial options will be collected under this program; however, this work plan is oriented toward the collection of hydrogeologic data to be used as input into groundwater flow and solute transport models in support of intrinsic remediation for restoration of groundwater contaminated with benzene, toluene, ethylbenzene, and xylene (BTEX).

As used in this report, the term "intrinsic remediation" refers to a management strategy that relies on natural attenuation mechanisms to remediate contaminants dissolved in groundwater and to control receptor exposure risks associated with contaminants in the subsurface. "Natural attenuation" refers to the actual physical, chemical, and biological processes that facilitate intrinsic remediation. Mechanisms for natural attenuation of BTEX include advection, dispersion, dilution from recharge, sorption, volatilization, and biodegradation. Of these processes, biodegradation is the only mechanism working to transform contaminants into innocuous byproducts. Intrinsic bioremediation occurs when indigenous microorganisms work to bring about a reduction in the total mass of contamination in the subsurface without the addition of nutrients. Patterns and rates of intrinsic remediation can vary markedly from site to site depending on governing physical and chemical processes.

As part of the TS, the contaminant fate and transport modeling effort has three primary objectives: 1) predict the future extent and concentration of dissolved contaminant plumes by modeling the effects of advection, dispersion, sorption, and biodegradation; 2) assess the possible exposure of potential downgradient receptors to contaminant concentrations that exceed levels intended to be protective of human health and the environment; and 3) to provide technical support for selection of the intrinsic remediation option as the best remedial alternative at regulatory negotiations, as appropriate. The modeling efforts for the PS-2 site at Fairchild AFB will involve completion of several tasks, which are described in the following sections.

This work plan was developed following discussions among representatives from the Air Force Center for Environmental Excellence (AFCEE), 92nd Civil Engineering Squadron--Environmental (92 CES/CEVR), and Parsons ES at a meeting held at the Base on July 11, 1995, to discuss the statement of work (SOW) for this project, and on a review of existing site characterization data. All field work will follow the health and safety procedures presented in the program *Health and Safety Plan for Bioplume II Modeling Initiative* (ES, 1993), and the site-specific addendum to the program Health and Safety Plan. This work plan was prepared for AFCEE and 92 CES/CEVR.

## 1.1 SCOPE OF CURRENT WORK PLAN

The ultimate objective of the work described herein is to provide a TS for remediation of groundwater contamination at PS-2. However, this project is part of a larger, broad-based initiative being conducted by AFCEE in conjunction with the US Environmental Protection Agency (USEPA) and Parsons ES to document the biodegradation and resulting attenuation of fuel hydrocarbons and solvents dissolved in groundwater, and to model this degradation using numerical and analytical groundwater model codes. For this reason, the work described in this work plan is directed toward the collection of data in support of this initiative. Data required to develop a 30-percent design of an alternate groundwater remediation system, should intrinsic remediation not prove to be a viable remedial option at this facility, also will be collected under this program. This work plan describes the site characterization activities to be performed by personnel from Parsons ES and the USEPA's Subsurface Protection and Remediation Division, formerly the USEPA's Robert S. Kerr Environmental Research Laboratory, in support of the TS and the groundwater modeling effort. Field activities will be performed to determine the extent of mobile and residual light nonaqueous-phase liquid (LNAPL) and dissolved contamination at PS-2. The data collected during the TS will be used along with data from previous investigations to complete the characterization of contamination at the site, and for use in the groundwater flow and solute transport models to make predictions of the future concentrations and extent of contamination.

Site characterization activities in support of the TS will include: 1) determination of preferential contaminant migration and potential receptor exposure pathways; 2) soil sampling using the Geoprobe® direct- push technology; 3) groundwater monitoring point placement; 4) groundwater sampling; and 5) aquifer testing. The materials and methodologies to accomplish these activities are described herein. Previously reported site-specific data and data collected during the supplemental site characterization activities described in this work plan will be used as input for the groundwater flow and solute transport models. Where site-specific data are not available, conservative values for the types of aquifer materials present at the site will be obtained from widely accepted published literature and used for model input. Sensitivity analyses will be conducted for the parameters that are known to have the greatest influence on the model results, and where possible, the model will be calibrated using historical site data. Upon completion of the modeling, Parsons ES will provide technical assistance at regulatory negotiations to support the intrinsic remediation option if the results of the modeling indicate that this approach is warranted. If it is shown that intrinsic remediation is not the most appropriate remedial option, Parsons ES will recommend the most appropriate groundwater remedial technology on the basis of available data.

This work plan consists of six sections, including this introduction. Section 2 presents a review of available previously reported, site-specific data and conceptual models for the site. Section 3 describes the proposed sampling strategy and procedures to be used for the collection of additional site characterization data. Section 4 describes the remedial option evaluation procedure and TS report format. Section 5 describes the quality assurance/quality control (QA/QC) measures to be used during this project. Section 6 contains the references used in preparing this document. There are two appendices to this work plan. Appendix A contains a listing of containers, preservatives, packaging, and shipping requirements for soil and groundwater samples. Appendix B contains summary site data, including available well logs, and summaries of historical soil and groundwater analytical data from previous field investigation work.

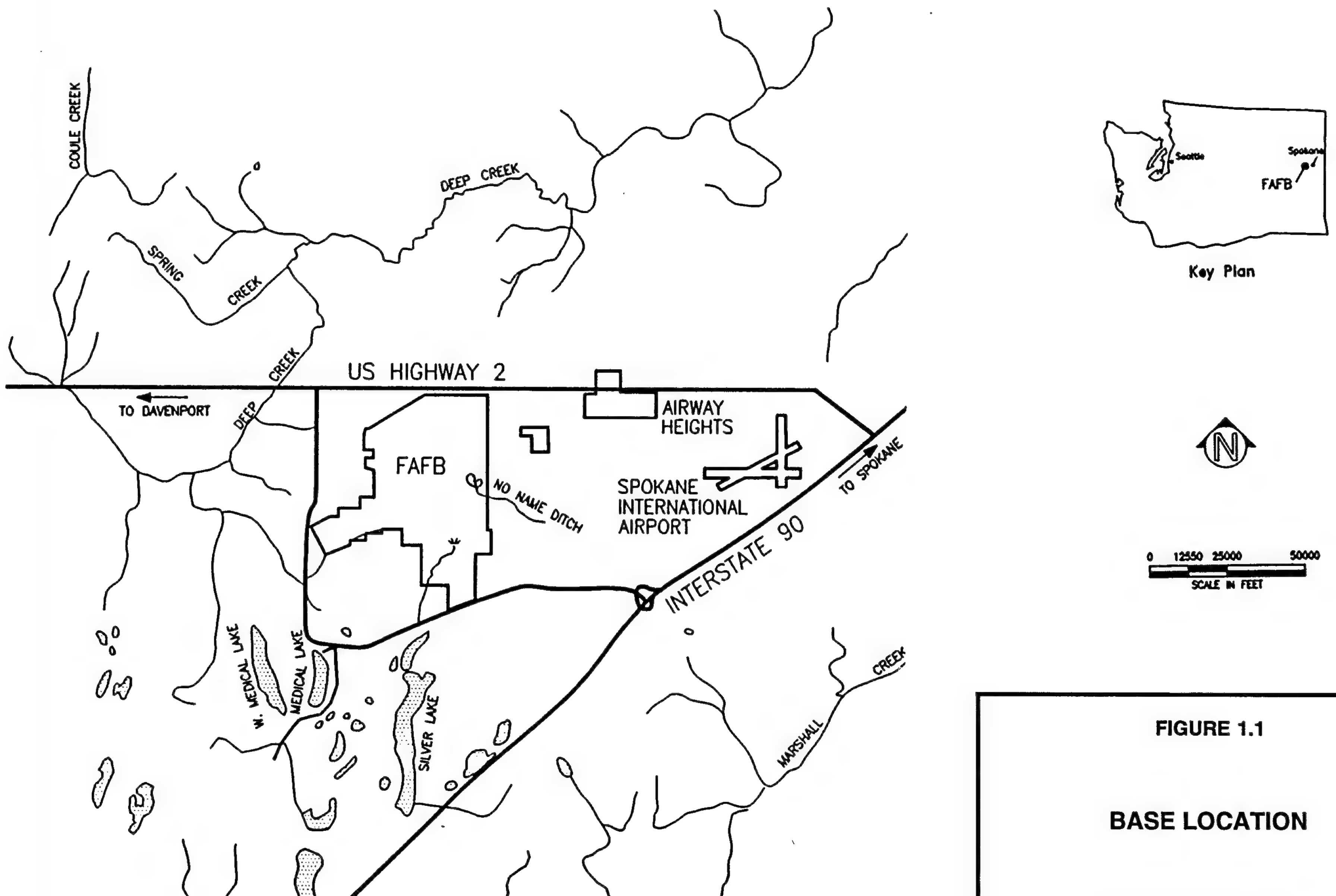
## 1.2 BACKGROUND

Fairchild AFB occupies an area of approximately 4,300 acres 12 miles west of Spokane, Washington (Figure 1.1). The Base is divided roughly in half by the main northeast/southwest runway (Figure 1.2). Aircraft operational facilities, approximately 1,600 Base housing units, an elementary school, a hospital, and support facilities for the tenants housed on-Base lie north of the runway. The air traffic control tower, weapons storage area, and survival training school lie to the south of the runway [Halliburton NUS (HNUS), 1993].

The Base was established in 1942 as an Army repair depot and transferred to the Strategic Air Command (SAC) in 1947. In 1992, Base control was transferred to the Air Combat Command (ACC). Currently, the Base is operated by the Air Mobility Command (AMC) and serves as host to the 92nd Air Refueling Wing. The Base is also the current home of the 141st Air Refueling Wing of the Washington Air National Guard (WANG), aircraft operational facilities, a weapons storage area, and a survival training school. Base operations employ approximately 5,000 civilian and military personnel (ES, 1994).

PS-2 is an active aircraft fueling/defueling station located on the flightline in the western portion of the Base and is a part of the flightline operational unit (OU-1). More specifically, PS-2 is located along Taxiway 1, in front of Buildings 1029, 1033, and 1037 in the WANG portion of Fairchild AFB (Figure 1.3). The site is covered by a broad expanse of asphalt and concrete with five refueling/defueling pits (Pits 17 through 21) located within the site boundaries (ES, 1994).

Two fuel spills have been documented at PS-2. In 1984, the fuel tank at defueling/refueling Pit 18 is known to have leaked up to 120 gallons of JP-4 jet fuel (HNUS, 1993). In 1985, an estimated 5,000 gallons of JP-4 was spilled when a fuel line flange cracked at Pit 21, located south of Building 1037. Reportedly, 4,000 gallons of fuel were recovered during the following 4 days. The spill overflowed the storm sewer system at the manhole in front of Building 1033, 400 feet downgradient. Fuel was also detected in a sewer junction box an additional 600 feet further downgradient from the release point. Approximately 100 gallons of fuel was pumped from this sewer junction box onto a grassy area east of Building 1029. Areas reportedly affected by the spills are indicated on Figure 1.3.




Source: ICF Technology Inc., 1995.

**FIGURE 1.1**

**BASE LOCATION**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

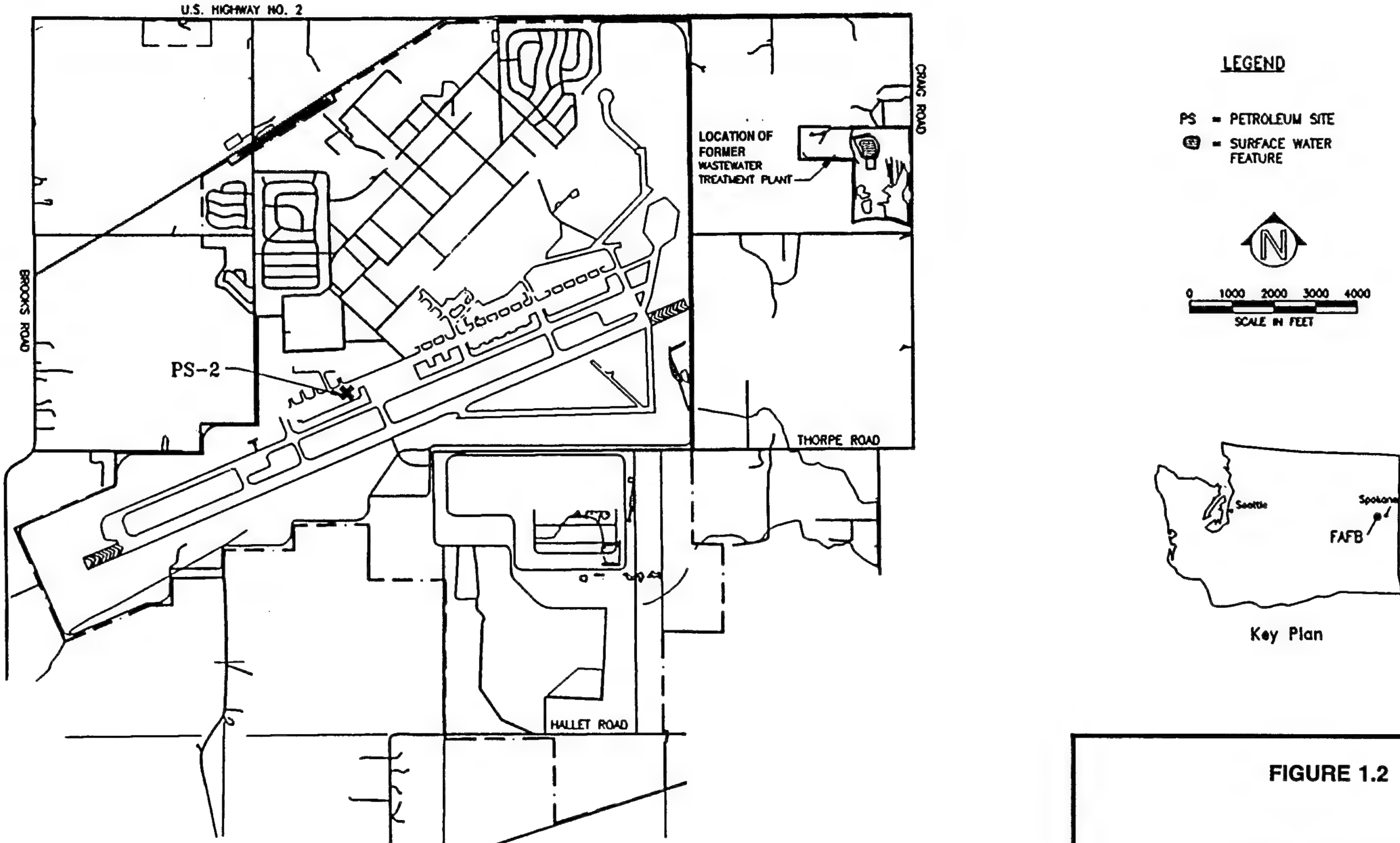



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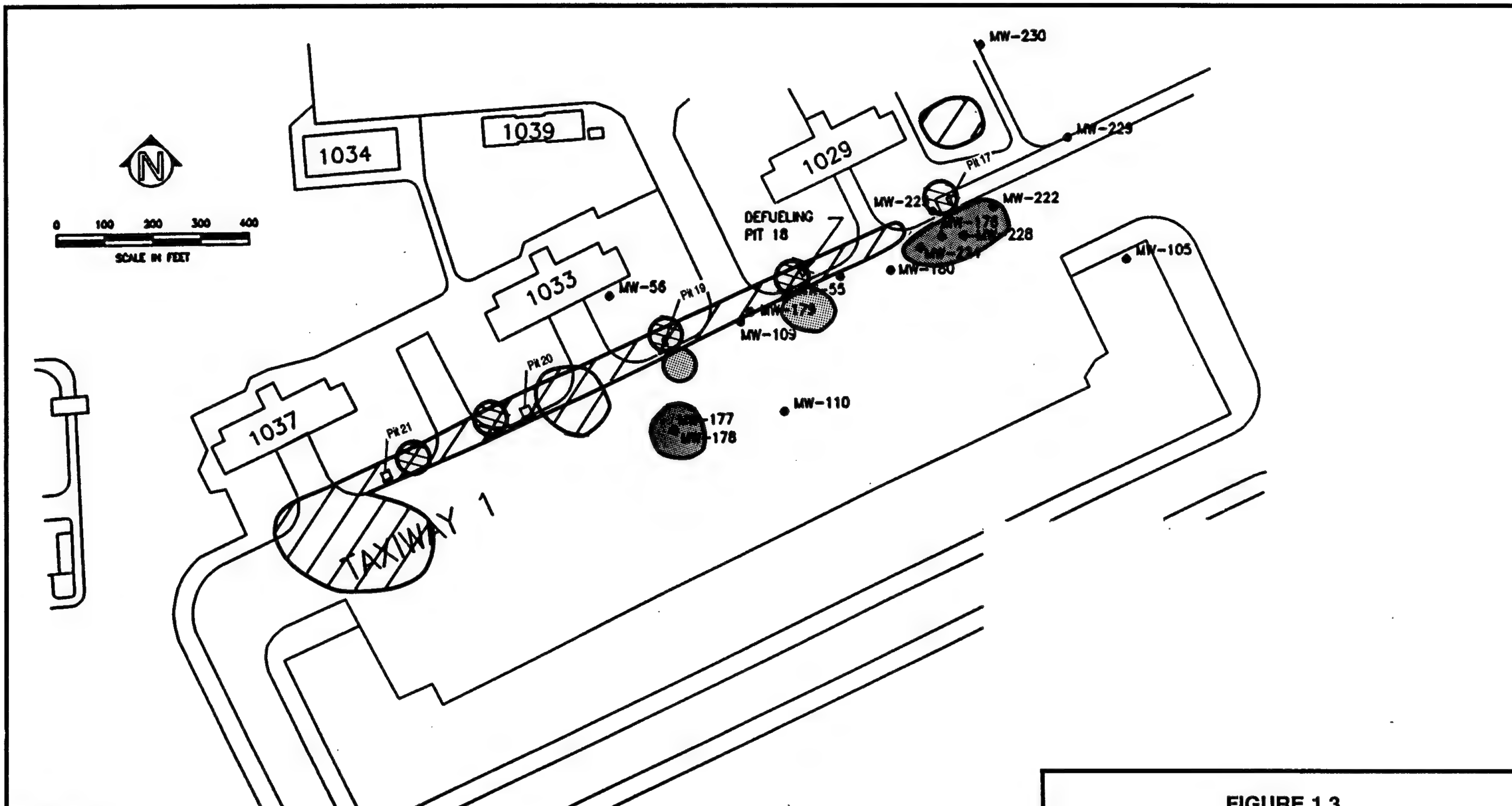
FIGURE 1.2

SITE LOCATION

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado




LEGEND

AREAS DOCUMENTED TO HAVE BEEN INPACTED DURING 1985 AND 1984 FUEL SPILLS.

LOCATIONS KNOWN TO CONTAIN FUEL TRANSFER EQUIPMENT.

REGIONS OF UNSATURATED SOIL CONTAMINATION.

REGIONS OF MOBILE LNAPL.

MW-112 MONITORING WELL

Sources: ICF Technology Inc., 1995.

FIGURE 1.3

SITE PS-2 LAYOUT

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Investigations were initiated at PS-2 as a result of the reported spills and the identification of petroleum product in the groundwater during flightline foundation drilling. The groundwater contamination later was confirmed in the Installation Restoration Program (IRP) Phase II study by Battelle Laboratories (1989). Since that time, a remedial investigation (RI) has been completed by HNUS (1993), a long-term monitoring report has been completed by ICF Technology (ICF, 1995), a source removal TS has been completed by HNUS (1994 , 1995a and 1995b), an interim bioventing report has been completed by ES (1994), and an analytical informal technical information report (ITIR) for long-term groundwater monitoring has been submitted by EA Engineering, Science, and Technology and Montgomery Watson Americas, Inc. (ES&T and MWA), (1995).

To date, mobile LNAPL has been identified in the vicinity of monitoring wells MW-177 and MW-176 (HNUS, 1993). LNAPL also was found in a vapor monitoring point during the installation of a bioventing pilot test system in the vicinity of defueling/refueling Pit 19. The soils near defueling/refueling Pit 19 were heavily contaminated with fuel hydrocarbons and residual LNAPL and are a probable continuing source of groundwater contamination (ES, 1994). The relationship between these three source areas and the former spills is unclear. The three source areas are identified on Figure 1.3. It is suspected that other unidentified sources also may be present at the site; all previously documented fuel distribution facilities are identified on Figure 1.3.

# SECTION 2

# DATA REVIEW AND CONCEPTUAL MODEL DEVELOPMENT

Previously reported site-specific data were reviewed and used to develop a conceptual site model (CSM) for the groundwater flow and contaminant transport conditions at PS-2. The CSM guides the development of sampling locations and analytical data requirements needed to support the modeling efforts and to evaluate potential remediation technologies, including intrinsic remediation. Section 2.1 presents a synopsis of available site characterization data. Section 2.2 presents the preliminary conceptual groundwater flow and contaminant transport model that was developed based on these data.

## 2.1 DATA REVIEW

The following sections are based upon review of data from the following sources:

- Remedial Investigation/Feasibility Study (RI/FS) Site Characterization Summary Report Priority 1 Sites Fairchild AFB [Science Applications International Corporation (SAIC), 1990];
- IRP Remedial Investigation Report (HNUS, 1993);
- Bioventing Pilot Test Results Report for PS-2, PS-1A, PS-1B, Building 2034, and Building 2035 (ES, 1994);
- Work Plan for Floating Free Product Passive Recovery TS (HNUS, 1994a);
- Floating Free Product Passive Recovery TS Letter Reports 07, 08, and 09 (HNUS, 1994b, 1995a, and 1995b);
- Long Term Monitoring Report For Priority 1 Sites SW-1 (LF-01), PS-2 (SS-18), and PS-8 (SS-26) at Fairchild AFB, Washington (ICF, 1995); and
- Analytical ITIR: Long-Term Monitoring, April Sampling Craig Road Landfill and Priority Sites SQ-1 PS-2, PS-8, and FT-01 (ES&T and MWA, 1995).

Several other reports contain site information that may be useful during the development of fate and transport models. These documents, which were unavailable during the development of this work plan, include:

- IRP Phase II, Stage 1 Confirmation/Qualification, Stage 1 Fairchild AFB (Battelle Laboratories, 1989); and

- IRP Phase I Records Search, 92nd Bombardment Wing, Fairchild AFB (JRB Associates, 1985).

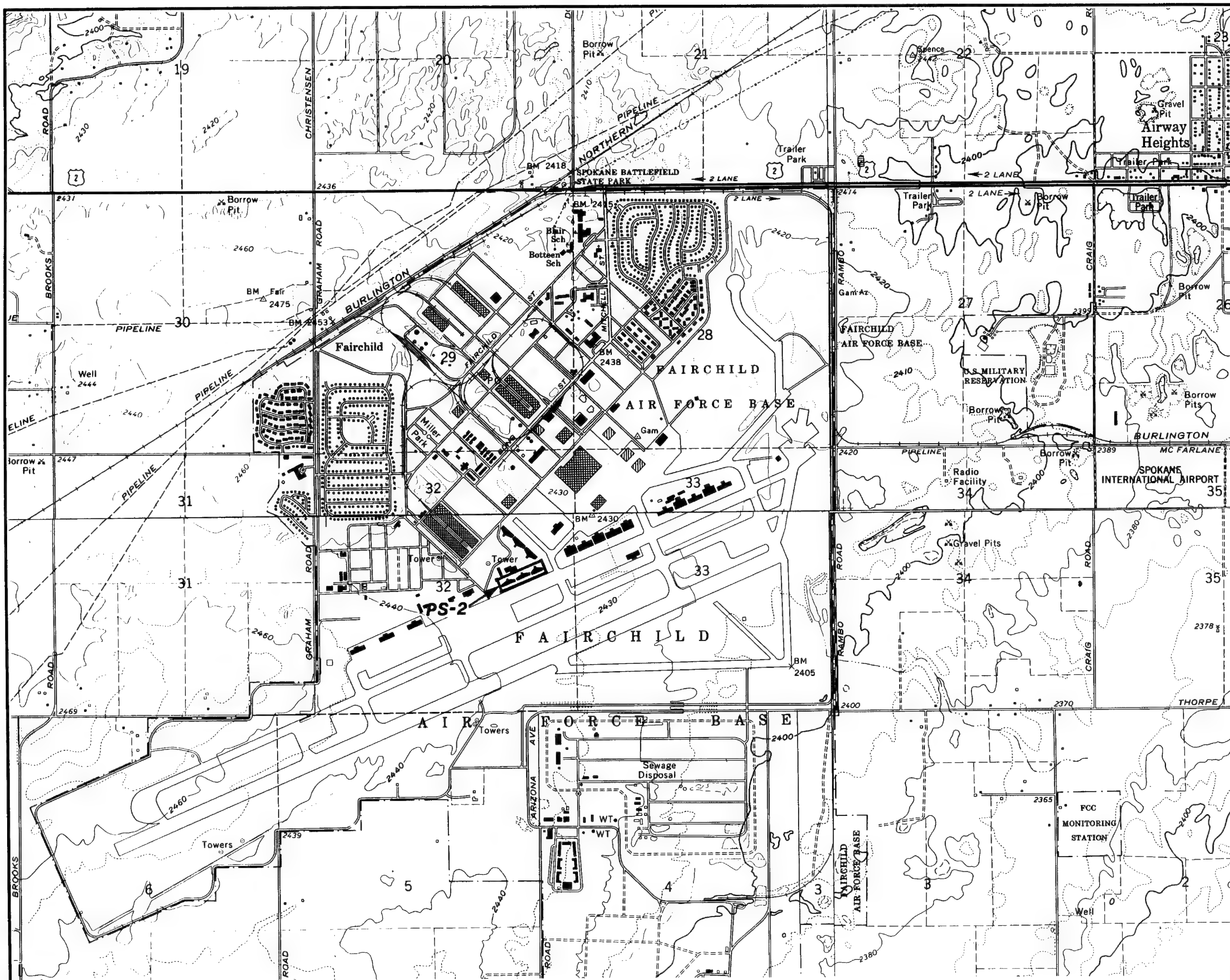
### 2.1.1 Topography, Surface Hydrology, and Climate

Fairchild AFB is located within the Columbia Basin in the northeastern corner of the 55,000-square-mile Columbia Plateau Physiographic Province (ICF, 1995). The Columbia Plateau is bordered by mountains and highlands on all side. The northern edge of the Plateau gives way to the Okanogan Highlands roughly 75 miles north of Fairchild AFB, while the eastern end of the Plateau is bordered by the Rocky Mountains, approximately 75 miles east of Fairchild AFB. The Plateau extends approximately 250 miles to the south and west of the Base; the Blue Mountains border the Plateau on the south, and the Cascade Mountains border the Plateau on the west. There is a watershed divide in the center of the Plateau that causes streams north of this divide to flow in a northerly direction, and streams south of the divide to flow in a southerly direction. The topography of the region was shaped by glacial flood waters which deeply that eroded the surface of the Columbia Plateau during the Pleistocene Epoch (approximately 22,000 years ago) (HNUS, 1993). The surface topography of the Base and surrounding region is generally flat to gently rolling grasslands sloping slightly to the east-northeast. Ground surface elevations on the Base range from 2,400 to 2,460 feet above mean sea level (ft msl) (Figure 2.1).

Fairchild AFB is locate in the northern half of the Columbia Plateau, north of the of the watershed divide. All surface water drainage in this region of the Columbia Plateau generally flows to the north or northwest (Flint, 1936). The Base is approximately 7 miles west-southwest of the Spokane River, which flows through the city of Spokane (USGS, 1973a, 1973b, 1986a, and 1986b). Two other drainages in the vicinity of the Base are Deep Creek and Marshall Creek, located approximately 2 miles northwest and 8 miles southeast of the Base, respectively. These creeks flow northwest and join the Spokane River, which drains this region of the Plateau. Surface water on the Base is generally limited to precipitation runoff. Surface water drainage is controlled within a series of manmade ditches. Reportedly, water collected in the ditch system does not leave Base property and surface water either infiltrates the subsurface or evaporates (HNUS, 1993).

Surface runoff at PS-2 is controlled through storm sewers that run parallel to Ladder Taxiway No. 1 (Figure 1.3). Three storm sewer lines drain the tarmac to the northeast where one main line collects all three storm sewer lines and eventually flows southeast into the wastewater lagoons (WW-1) located in the southern corner of the base. A map of these sewer lines is included in Appendix B. Buildings 1027, 1033, and 1029 have floor drains which pass through oil/water separators. The effluent from the separators flows into the storm sewer network (HNUS, 1993).

Fairchild AFB is surrounded by semi-arid grasslands common to this area of the Columbia Basin. The Base receives approximately 16 inches of rainfall during the warm dry summers, and 40 inches of snowfall during the cool, damp winter months. The prevailing wind direction in the region is to the northeast at an average speed of 8 miles per hour (ICF, 1995). The average evapotranspiration rate for the region is reported at 12.8 inches per year (JRB Associates, 1985). Maximum infiltration rates usually occur during the early spring when snow melt runoff combines with




Sources: USGS, 1973A, 1973B, 1973C, and 1986.

**FIGURE 2.1**

**REGIONAL TOPOGRAPHIC BASE MAP**

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.

precipitation while temperatures are still cool and evapotranspiration is low (SAIC, 1990).

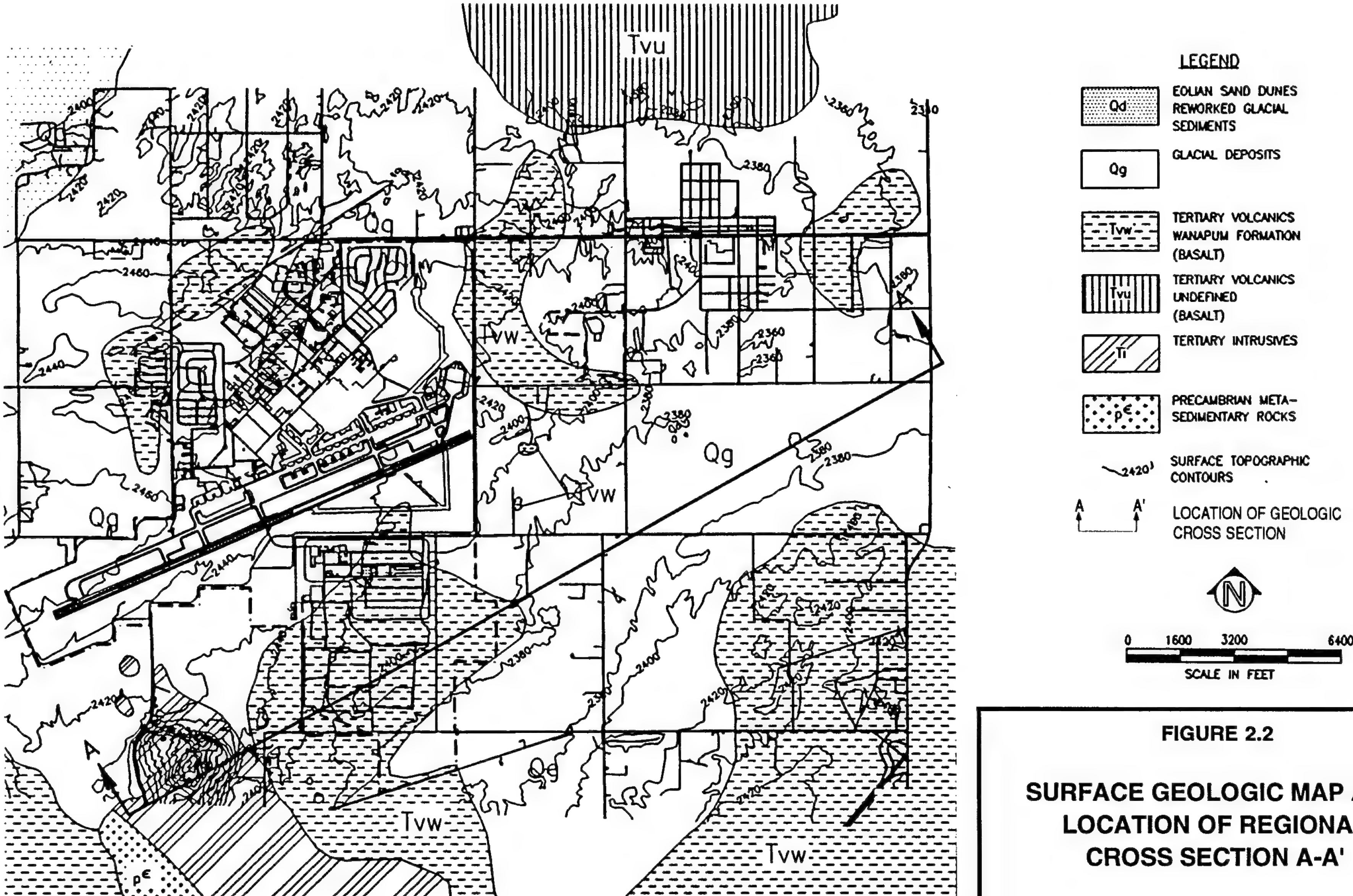
### 2.1.2 Overview of Geology and Hydrogeology

#### 2.1.2.1 Regional Geology and Hydrogeology

The shallow subsurface geology at Fairchild AFB is a mixture of Quaternary sediments consisting of eolion, glacial, fluvial, lacustrine, and catastrophic flood deposits (Figure 2.2). Flood waters from the glacial-era Missoula Lake scoured the basalt bedrock of this region of the Columbia Plateau. Coarse sediments were deposited during the early recession of flood waters, followed by finer sediments during the later stages of floodwater recession. The alluvium in the vicinity of the Base generally consists of fine-grained sediments deposited by receding glacial flood waters. Clays and silts are intermixed with sandy silts, clays, and gravels (SAIC, 1990). Additionally, loess (windblown silt) deposits are interbedded in portions of the alluvium. Alluvial deposits are generally follow the slope of the underlying basalt bedrock (ICF, 1995).

Bedrock in the vicinity of the Base is mostly Tertiary Basalts of the Columbia River Group. Basalts below Fairchild AFB are of the Wanampum Formation (HNUS, 1993). The basalt flows in the region are interbedded with sedimentary clay and silt units of the of the Latah Formation. These layers were deposited when stream beds were isolated by the volcanic basalt flows (Cline, 1969). The Wanampum Basalt flow below the Base appears to be divided into an upper and lower flow sequence by an interbed of the Latah Formation (Figure 2.3). The upper basalt flow is 166 feet to 193 feet thick across the Base. The surface of the upper basalt flow is vesiculated, deeply fractured, and highly weathered in places. Just east of the Base the upper basalt layer was completely eroded away by the Missoula Lake flood waters. The middle of this flow contains few vesicles and fractures; the formation becomes more massive and competent with depth. The underlying Latah Formation deposits consist of an extensive silty claystone that ranges in thickness from 8.5 to 10 feet (SAIC, 1990). Information on the geologic characteristics of the lower basalt flow was not available in the previous reports reviewed as part of this work plan; however, information on the lower basalt flow is not considered to be vital to the formation of the CSM for data collection in support intrinsic remediation at PS-2.

Groundwater in the vicinity of the Base is encountered between 8 to 12 feet below ground surface (bgs) and is found in both the alluvial overburden material and the underlying basalt bedrock. Groundwater flow in the alluvium is through intergranular pore space, while flow in the basalt is through interconnecting fractures (HNUS, 1993). Flow across the Base is generally to the east and east-northeast, but local variations may result from local changes in bedrock topography (Figure 2.4). Groundwater in the overburden and shallow bedrock is generally unconfined, with some local semiconfined areas. The overburden and the shallow basalt are hydraulically connected by fractures, vesicles, and weathered zones. The middle region of the shallow basalt flow is more competent with less fracturing, and acts as an aquitard. The interbedded claystone between the basalt flows also acts as a confining layer (HNUS, 1993).




Source: ICF Technology Inc., 1995.

**FIGURE 2.2**

**SURFACE GEOLOGIC MAP AND LOCATION OF REGIONAL CROSS SECTION A-A'**

Intrinsic Remediation TS
Fairchild AFB, Washington

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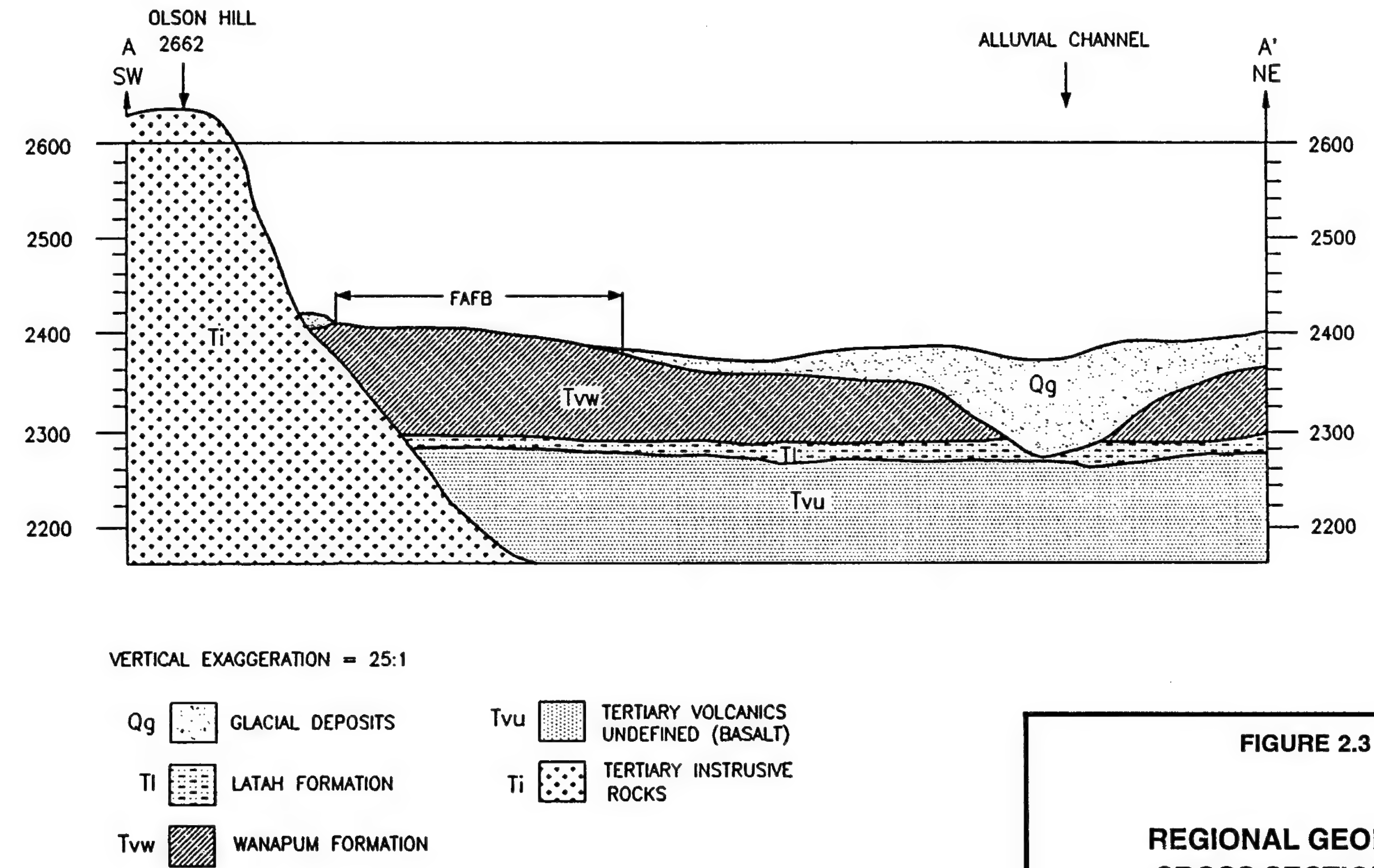
Denver, Colorado




Source: ICF Technology Inc., 1995.

**FIGURE 2.3**

**REGIONAL GEOLOGIC CROSS SECTION A-A'**

Intrinsic Remediation TS
Fairchild AFB, Washington

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Denver, Colorado

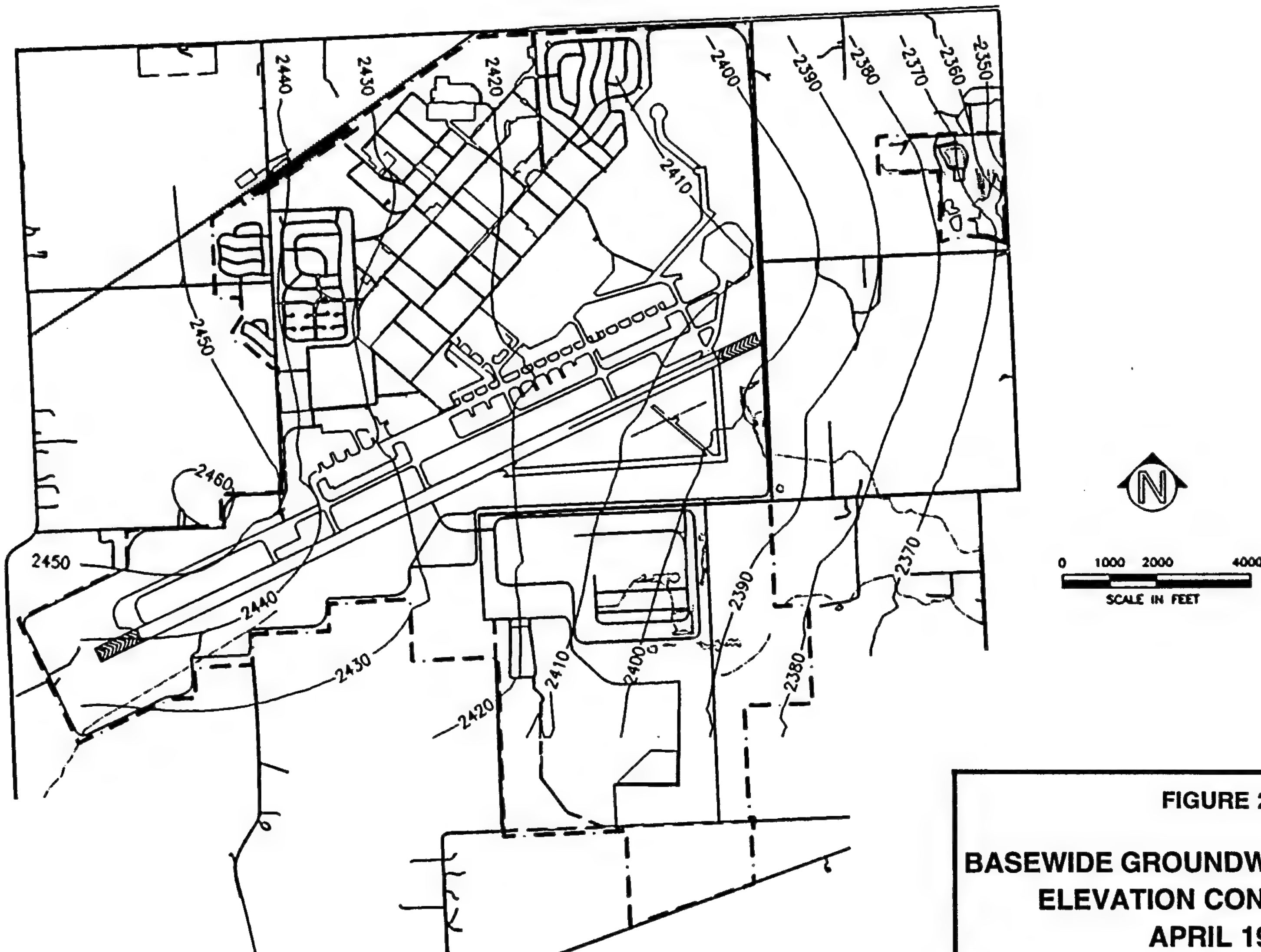



FIGURE 2.4

**BASEWIDE GROUNDWATER SURFACE ELEVATION CONTOUR MAP APRIL 1993**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

**Source: ICF Technology Inc., 1995.**

Recharge of the aquifer under the Base is expected to come from upgradient flow and surface runoff infiltration. Shallow groundwater in the vicinity of the Base is not known to be used as a drinking water supply. Neighborhoods to the east and northeast of the Base obtain domestic and agricultural water primarily from private wells which tap aquifers in the deeper basalt flows. The closest residential neighborhoods are roughly 1.5 miles downgradient from the site, near the eastern boundary of the Base. Base drinking water is primarily supplied from a Base-owned well field 10 miles northwest of the Base. Additionally, there is a water supply well located in the southern area of the Base. This well also produces water from the basalt aquifer and supplies roughly 10 percent of the Base's needs (HNUS, 1993).

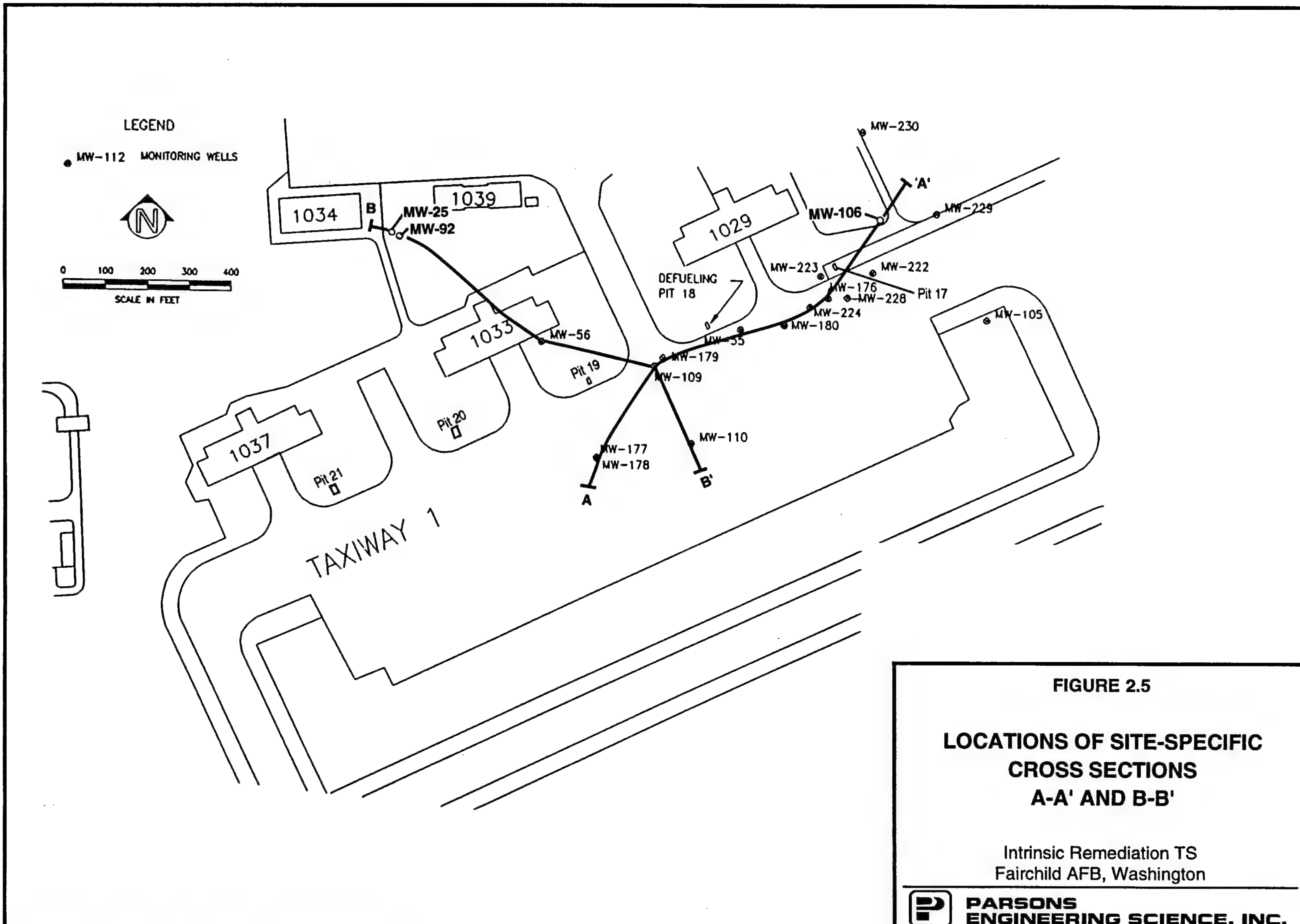
#### 2.1.2.2 PS-2 Geology and Hydrology

Most of the ground surface at PS-2 is covered by concrete and asphalt pavement for parking, maintenance, and fueling of aircraft. The thicknesses of the concrete and asphalt are not available at this time; however, the concrete pavement is expected to be at least 8 inches thick. On the basis of information collected during the RI and other previous investigations, the overburden at PS-2 is from 15 to 24 feet thick. Sediments at PS-2 consist primarily of poorly sorted silty and gravelly sands and sandy gravels. A clay and sandy clay layer was encountered just above the overburden basalt interface in several wells installed as part of the RI. The upper flow zone basalt layer below the alluvial deposits is massive, moderately fractured, and shows traces of weathering near the overburden basalt interface (HNUS, 1993).Figure 2.5 shows the location of stratigraphic cross sections A-A' and B-B'. Figure 2.6 presents cross section A-A' which is oriented in a northeast-southwest direction along the axis of groundwater flow. Figure 2.7 presents cross section B-B', oriented perpendicular to the direction of groundwater flow in a northwest-southeast direction.

Borehole logs from the vent well (VW-1) and vapor monitoring points (VMPs) installed during the bioventing pilot test near defueling pit 19 showed that soils from the surface to 2 feet bgs were a gray to grayish-green gravelly sand. Below 2 feet soils were mostly a brown to greenish-gray silty sand with minor gravel. Soils from both intervals exhibited a noticeable fuel odor. A clean sand lens was encountered roughly 5 feet bgs, and a dark-brown clay lens was encountered at a depth of 9 feet bgs in the borehole associated with VW-1. The clay lens also exhibited a noticeable fuel odor (ES, 1994).

There are currently twenty-two groundwater monitoring wells at PS-2 including 3 wells with screening in the shallow basalt bedrock, and 17 wells with screening in the unconsolidated deposits. These wells were installed as part of the RI/FS site characterization investigation, the RI, the long-term monitoring program, and the mobile LNAPL recovery TS. Groundwater at the site resides in the Quaternary alluvium and in the underlying basalt bedrock. Available monitoring well construction details and recent well level data are presented in Table 2.1. Figure 2.8 shows the groundwater surface for PS-2 in October 1993. The groundwater surface shown on Figure 2.8 is very similar to those reported in previous site investigations reports, implying that groundwater flow patterns remained consistent.

In the immediate vicinity of the site, groundwater flows to the east-northeast, which is consistent with the regional flow direction. Groundwater elevations typically are




Sources: Halliburton NUS, 1993; and ICF Technology Inc., 1995.

**FIGURE 2.5**

**LOCATIONS OF SITE-SPECIFIC CROSS SECTIONS A-A' AND B-B'**

Intrinsic Remediation TS
Fairchild AFB, Washington

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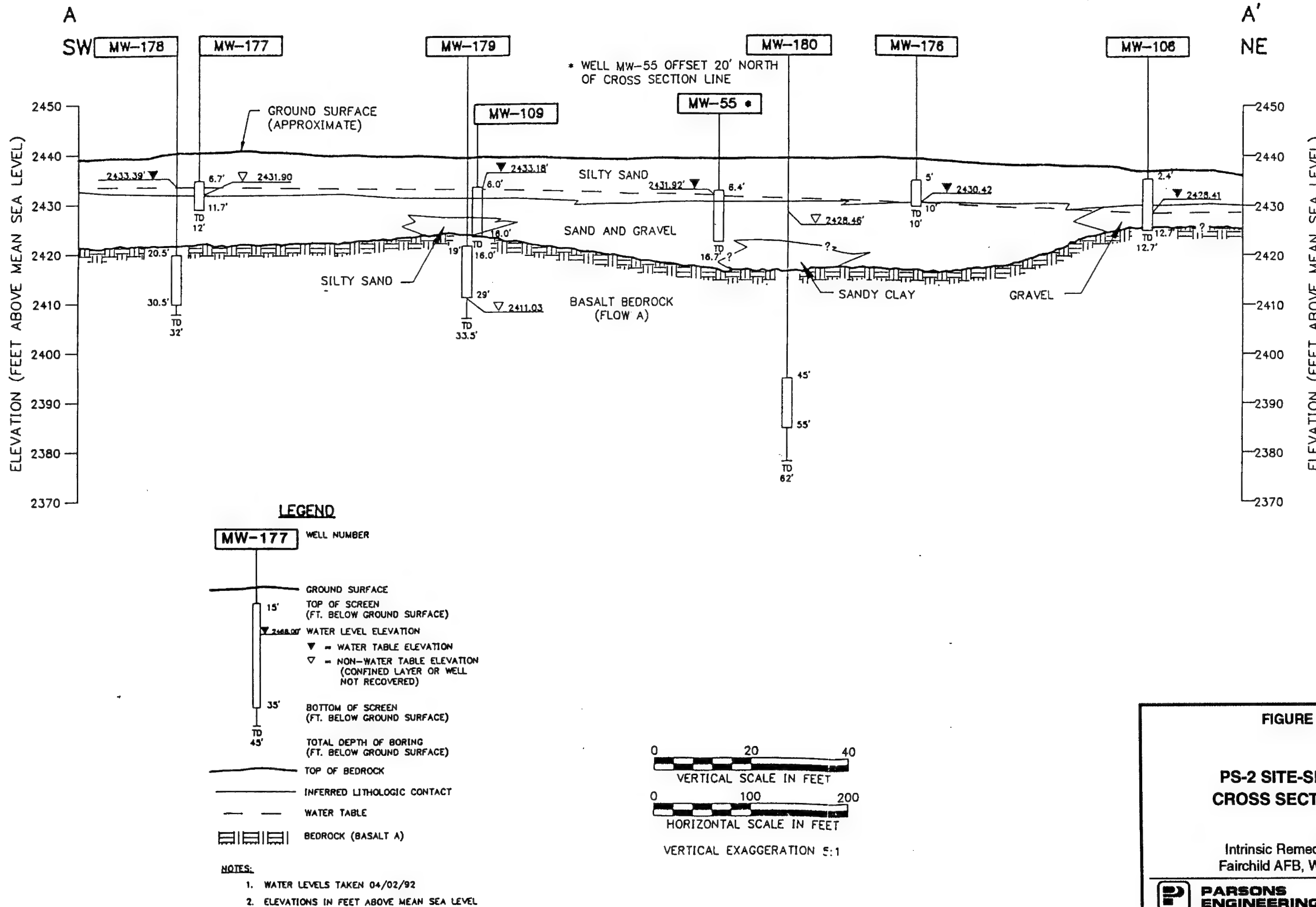
Denver, Colorado



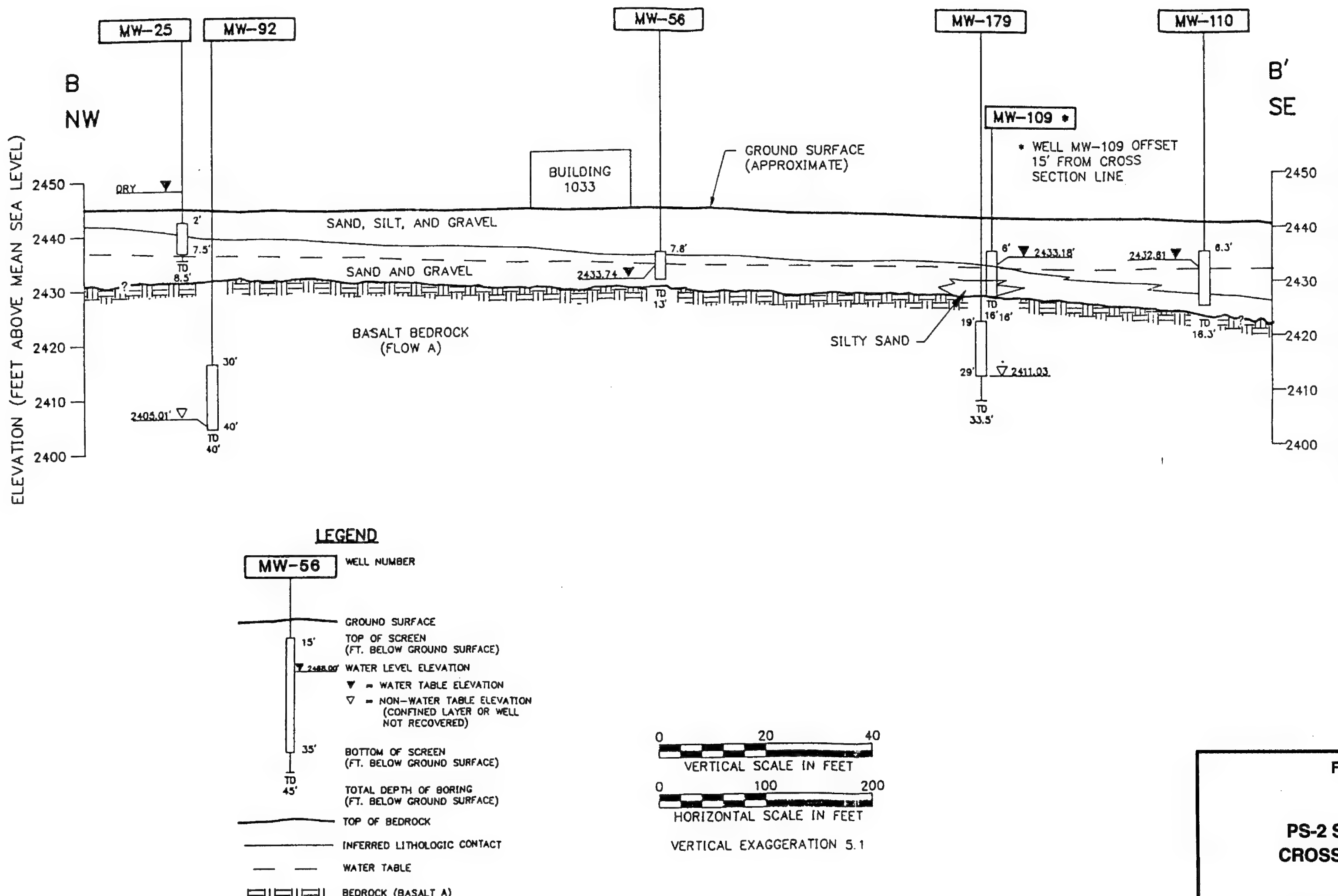

Sources: Halliburton NUS, 1993.

**FIGURE 2.6**

**PS-2 SITE-SPECIFIC CROSS SECTION A-A'**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**




NOTES:
1. WATER LEVELS TAKEN 04/01/92 AND 04/02/92
2. ELEVATIONS IN FEET ABOVE MEAN SEA LEVEL

Sources: Halliburton NUS, 1993.

**FIGURE 2.7**

**PS-2 SITE-SPECIFIC CROSS SECTION B-B'**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**

## TABLE 2.1
## SUMMARY OF WELL INSTALLATION DETAILS AND GROUNDWATER ELEVATION DATA, SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Well Identification | Sampling Event or Date | PVC Casing Size (inches) | Depth to Bottom of Well (feet bgs) | Screened Interval (feet bgs) | Elevation Top of PVC (feet amsl) | Ground Elevation (feet amsl) | Groundwater Elevation (feet amsl) | Source [a/] |
|---|---|---|---|---|---|---|---|---|
| MW-55 | 1988 | 2 | 16.6 | 6.35-16.60 | NA [b/] | NA | NA | 4 |
| | 11/17/92 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,431.66 | 3 |
| | 4/29/93 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,432.48 | 3 |
| | 7/27/93 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,432.16 | 3 |
| | 10/5/93 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,431.22 | 3 |
| | 2/8/94 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,431.82 | 3 |
| | 11/3/94 | 2 | 16.19 | | 2,439.36 | 2,439.72 | 2,431.82 | 3 |
| | 04/04/95 | 2 | 15.95 | | 2,439.36 | 2,439.72 | 2,432.78 | 2 |
| MW-56 | 1988 | 2 | 13.0 | 7.75-13.00 | NA | NA | NA | 4 |
| | 11/17/92 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,433.39 | 3 |
| | 7/27/93 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,434.10 | 3 |
| | 10/5/93 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,433.11 | 3 |
| | 2/8/94 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,433.70 | 3 |
| | 5/5/94 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,433.86 | 3 |
| | 8/3/94 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,433.53 | 3 |
| | 11/3/94 | 2 | 12.70 | | 2,442.18 | 2,442.55 | 2,434.00 | 3 |
| | 04/04/95 | 2 | 12.55 | | 2,442.18 | 2,442.55 | 2,434.64 | 2 |
| MW-105 | 1988 | 2 | 17.72 | 7.47-17.72 | NA | NA | NA | 4 |
| | 11/17/92 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.54 | 3 |
| | 4/29/93 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,429.36 | 3 |
| | 7/27/93 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,429.08 | 3 |
| | 10/5/93 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.57 | 3 |
| | 2/8/94 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.80 | 3 |
| | 5/5/94 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.85 | 3 |
| | 8/3/94 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.50 | 3 |
| | 11/3/94 | 2 | 15.26 | | 2,434.95 | 2,435.37 | 2,428.65 | 3 |
| MW-106 | 1988 | 2 | 12.69 | 2.44-12.69 | NA | NA | NA | 4 |
| MW-109 | 1988 | 2 | 15.99 | 5.99-15.99 | NA | NA | NA | 4 |
| | 11/17/92 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,433.12 | 3 |
| | 4/29/93 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,433.88 | 3 |
| | 7/27/93 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,433.68 | 3 |
| | 10/5/93 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,432.63 | 3 |
| | 2/8/94 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,432.77 | 3 |
| | 5/4/94 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,433.08 | 3 |

## TABLE 2.1 (Continued)
## SUMMARY OF WELL INSTALLATION DETAILS AND GROUNDWATER ELEVATION DATA, SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

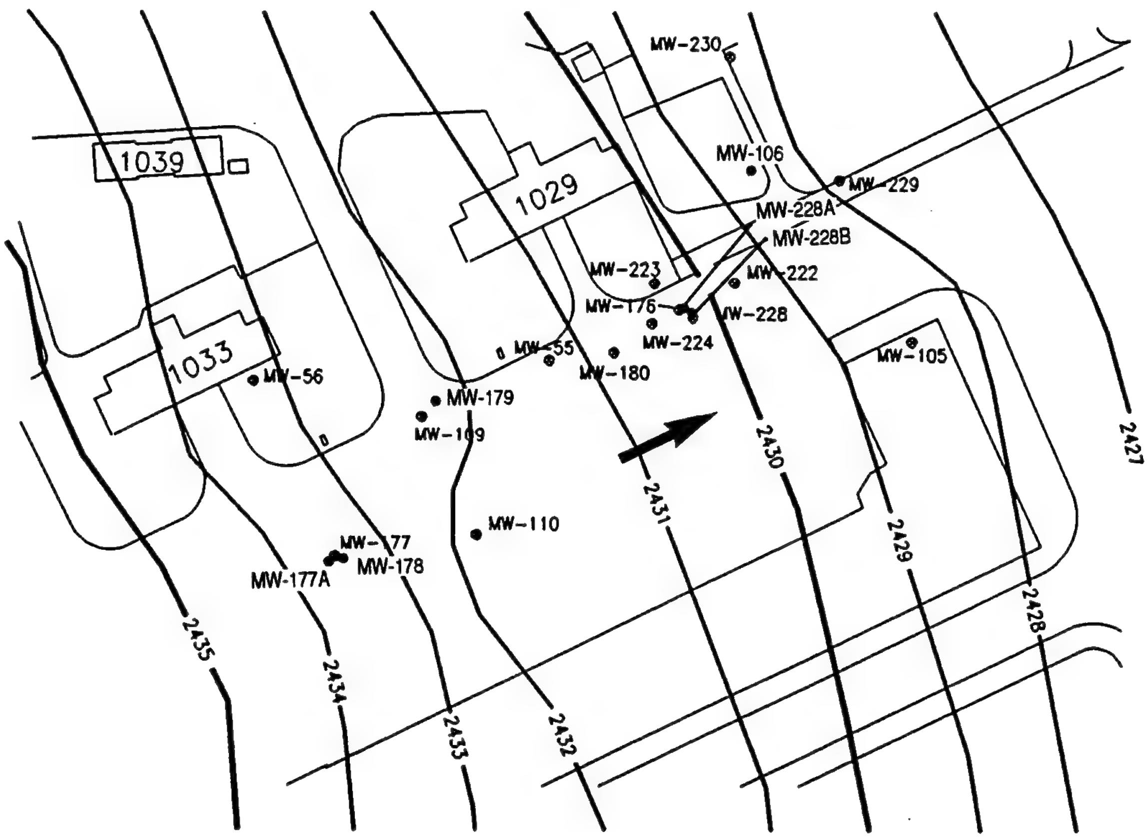
| Well Identification | Sampling Event or Date | PVC Casing Size (inches) | Depth to Bottom of Well (feet bgs) | Screened Interval (feet bgs) | Elevation Top of PVC (feet amsl) | Ground Elevation (feet amsl) | Groundwater Elevation (feet amsl) | Source [a/] |
|---|---|---|---|---|---|---|---|---|
| MW-109 | 11/3/94 | 2 | 14.95 | | 2,440.39 | 2,440.79 | 2,432.34 | 3 |
| | 04/04/95 | 2 | 14.65 | | 2,440.39 | 2,440.79 | 2,433.94 | 2 |
| MW-110 | 1988 | 2 | 16.27 | 6.27-16.27 | | | | 4 |
| | 11/17/92 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,432.38 | 3 |
| | 4/29/93 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,433.58 | 3 |
| | 7/27/93 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,432.96 | 3 |
| | 10/5/93 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,431.84 | 3 |
| | 2/8/94 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,432.44 | 3 |
| | 11/3/94 | 2 | 14.57 | | 2,440.56 | 2,440.82 | 2,434.34 | 3 |
| | 04/04/95 | 2 | 14.35 | | 2,440.56 | 2,440.82 | 2,433.76 | 2 |
| MW-176 | 09/91-12/91 | 2 | 10.0 | 5-9 | 2,439.09 | NA | NA | 1 |
| MW-177 | 09/91-12/91 | 2 | 12.0 | 6.7-11.7 | 2,440.70 | NA | NA | 1 |
| MW-177A | 1995 | 4 | 14.5 | NA | NA | NA | NA | 5 |
| MW-178 | 09/91-12/91 | 4 | 32.0 | 20.5-30.5 | 2,440.61 | NA | NA | 1 |
| | 11/17/92 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,433.60 | 3 |
| | 4/29/93 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,433.32 | 3 |
| | 7/27/93 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,434.27 | 3 |
| | 10/5/93 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,433.76 | 3 |
| | 2/11/94 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,433.12 | 3 |
| | 5/4/94 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,433.55 | 3 |
| | 8/2/94 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,432.83 | 3 |
| | 11/15/94 | 4 | 29.29 | | 2,440.45 | 2,440.83 | 2,415.14 | 3 |
| | 04/04/95 | 4 | 29.32 | | 2,440.45 | 2,440.83 | 2,434.63 | 2 |
| MW-179 | 09/91-12/91 | 4 | 33.5 | 20.5-30.5 | 2,440.59 | NA | NA | 1 |
| | 11/17/92 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,411.37 | 3 |
| | 4/29/93 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,440.51 | 3 |
| | 7/27/93 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,440.46 | 3 |
| | 10/5/93 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,440.46 | 3 |
| | 2/11/94 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,418.10 | 3 |
| | 8/2/94 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,414.47 | 3 |
| | 11/15/94 | 4 | 30.35 | | 2,440.52 | 2,440.83 | 2,427.99 | 3 |
| | 04/04/95 | 4 | 30.25 | | 2,440.52 | 2,440.83 | 2,416.92 | 2 |

# TABLE 2.1 (Concluded)
## SUMMARY OF WELL INSTALLATION DETAILS AND GROUNDWATER ELEVATION DATA, SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Well Identification | Sampling Event or Date | PVC Casing Size (inches) | Depth to Bottom of Well (feet bgs) | Screened Interval (feet bgs) | Elevation Top of PVC (feet amsl) | Ground Elevation (feet amsl) | Groundwater Elevation (feet amsl) | Source [a/] |
|---|---|---|---|---|---|---|---|---|
| MW-180 | 09/91-12/91 | 4 | 62.0 | 45-55 | 2,439.20 | NA | NA | 1 |
| | 11/17/92 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,428.02 | 3 |
| | 4/29/93 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,429.39 | 3 |
| | 7/27/93 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,429.09 | 3 |
| | 10/5/93 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,428.33 | 3 |
| | 2/11/94 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,428.13 | 3 |
| | 5/4/94 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,428.15 | 3 |
| | 8/2/94 | 4 | 54.63 | | 2,438.97 | 2,439.45 | 2,427.95 | 3 |
| | 04/04/95 | 4 | 54.55 | | 2,438.97 | 2,439.45 | 2,429.81 | 2 |
| MW-222 | 1995 | 4 | 15.48 | NA | NA | NA | NA | 5 |
| MW-223 | NA | 4 | NA | NA | NA | NA | NA | 5 |
| MW-224 | 1995 | 4 | 15 | NA | NA | NA | NA | 5 |
| MW-228 | 1995 | 4 | 15.93 | NA | NA | NA | NA | 5 |
| MW-228A | 1995 | 4 | 20.04 | NA | NA | NA | NA | 5 |
| MW-228B | 1995 | 4 | 16 | NA | NA | NA | NA | 5 |
| MW-229 | 11/18/94 | 4 | 15.52 | NA | 2,436.36 | 2,436.74 | 2,428.17 | 3 |
| MW-230 | 11/22/94 | 4 | 11.45 | NA | 2,435.93 | 2,436.26 | 2,427.47 | 3 |

[a/] Sources:
1. HNUS, 1993.
2. ES&T and MWA, 1995.
3. ICF, 1995.
4. SAIC, 1988.
5. Verbal corrospondance with bioventing pilot test field personnel.

[b/] NA = Information not available.



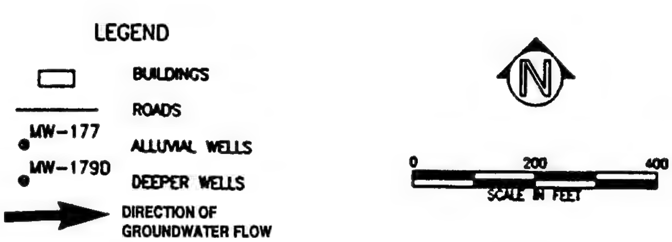




**FIGURE 2.8**

**GROUNDWATER SURFACE ELEVATIONS AT SITE PS-2 OCTOBER 1993**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

**Source: ICF Technology Inc., 1995.**

lower during August through November, and higher during April through July. Water table elevation fluctuations of up to 2 feet have been observed from November 1992 to November 1994 (ICF, 1995). Groundwater elevations measured in April 1992 indicate the hydraulic gradient in the vicinity of PS-2 steepens from 0.003 foot per foot (ft/ft) in the southwestern portion of the site to 0.006 ft/ft in the northeastern portion of the site (HNUS 1993). Similar gradients areis suggested by the 1993 groundwater elevation data presented in Figure 2.8 (ICF, 1995).

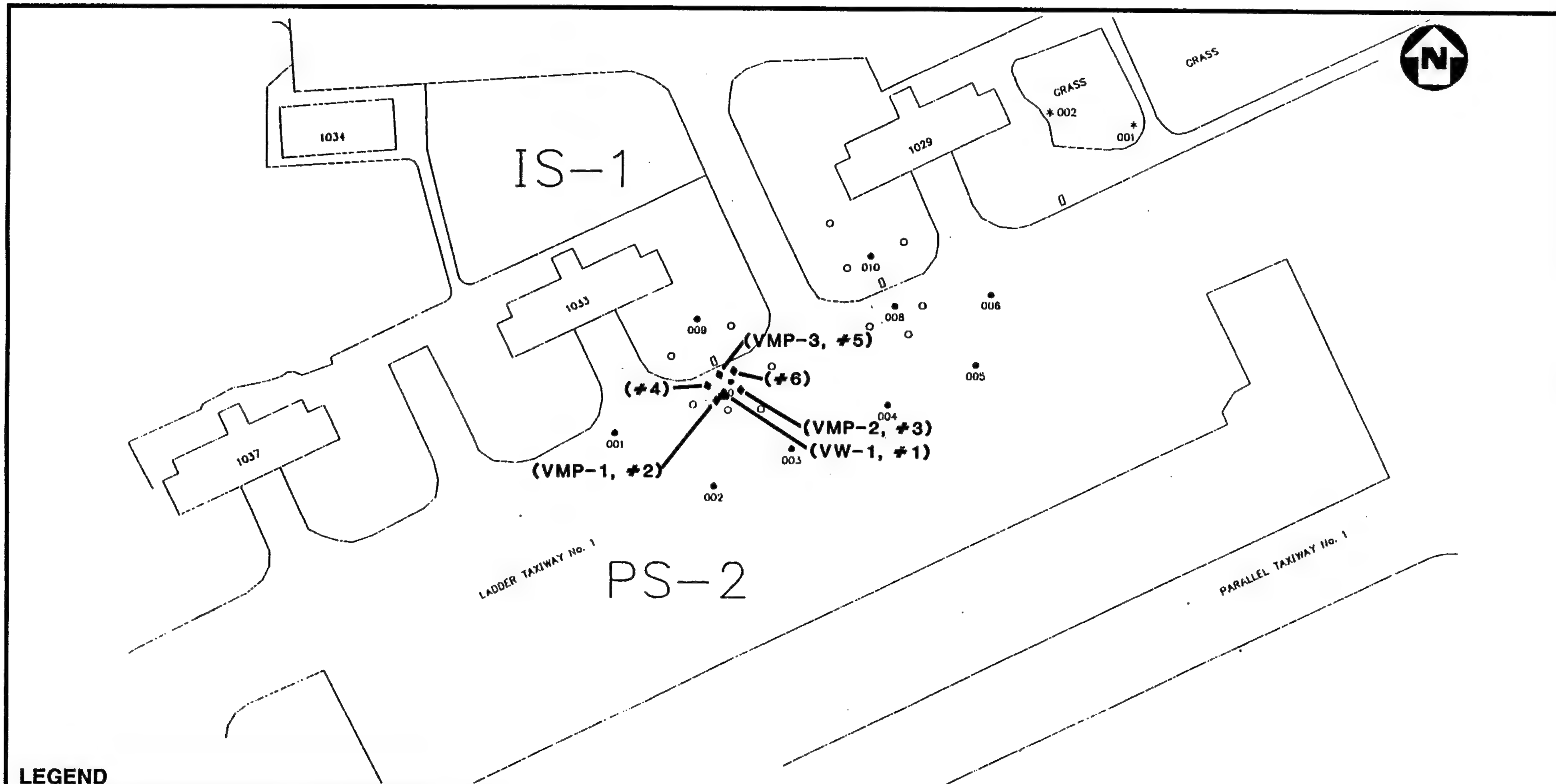
Three groundwater monitoring wells (MW-178, MW-179, and MW-180) were installed into the shallow basalt bedrock during previous investigations Figure 2.6). Groundwater data collected as part of the RI and the long-term monitoring program suggest that shallow bedrock groundwater elevations at MW-179 and MW-180 are consistently below groundwater elevations measured in surrounding alluvial wells. The groundwater elevation measured in MW-179 was nearly 5 feet lower than the groundwater elevation measured in the adjacent alluvial well MW-109, in November 1994. Additionally, the groundwater elevation measured in MW-180 was approximately 3.5 feet below the adjacent alluvial well MW-55, in February 1994. These data suggests vertical hydraulic gradients of 0.37 and 0.13 ft/ft in the vicinity of MW-179 and MW-180, respectively.

When pump testing was performed as part of the RI at alluvial well MW-55, drawdown was not observed in the two closest alluvial wells (MW-176 and MW-109). Using a semilog analysis (Theis 1935), estimates of transmissivity and hydraulic conductivity were calculated from residual drawdown observed in the pumping well, MW-55. Transmissivity was estimated at 212 square feet per day ($ft^2$/day) and hydraulic conductivity was estimated at 24 feet per day (ft/day) (HNUS, 1993). Another pump test was performed as part of the RI in the alluvial well, MW-67 at site PS-8, approximately 0.75/4 of a mile downgradient from PS-2. Again, drawdown was not measured in the closest observation, well and same analytical method was used to estimate the transmissivity and hydraulic conductivity from residual drawdown measurements collected from the pumping well. The estimated transmissivity and hydraulic conductivity from data collected at MW-67 were 2353 $ft^2$/day and 233 ft/day, respectively. The estimated values of transmissivity and hydraulic conductivity for the unconsolidated material at site PS-8 are significantly higher than the values estimated for the unconsolidated material at site PS-2. Other aquifer testing results were not available for review.

### 2.1.3 Summary of Analytical Data for PS-2

#### 2.1.3.1 Soil Gas Sampling and Analytical Results

Both the SAIC (1990) site investigation and the ES (1994) bioventing pilot study included soil gas measurements. A quantitative soil gas survey was conducted in 1990 by SAIC. However, the results of this survey were not available in reports reviewed as part of the preparation of this work plan. Limited soil gas measurements also were collected as part of the bioventing pilot test at PS-2 (Figure 2.9). Analytical sampling of soil gas for BTEX and total volatile hydrocarbons (TVH) was performed. Results of initial soil gas sampling during the pilot test indicated that soil gas in the immediate vicinity of Defueling Pit 19 had elevated concentrations of BTEX and TVH, and very low concentrations of oxygen. Table 2.2 presents the analytical results of BTEX and




**LEGEND**

- ● RI SUBSURFACE SOIL BORING LOCATIONS 002 AND LOCATION NUMBERS
- ○ HISTORIC SUBSURFACE SOIL BORING LOCATIONS
- * RI SURFACE SOIL SAMPLE LOCATION AND SEQUENCE NUMBER (TABLE 2-4)
- (VMP-1,#2) ◆ (BIOVENTING VAPOR MONITORING POINT LOCATION, BIOVENTING BOREHOLE LOCATION)
- VW-1 ▲ (BIOVENTING VENT WELL LOCATION, BIOVENTING BOREHOLE LOCATION)

Sources: Halliburton NUS, 1993; ES, 1994.

**FIGURE 2.9**

**LOCATIONS OF SOIL AND SOIL GAS SAMPLES COLLECTED DURING RI AND BIOVENTING PILOT TEST**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

## TABLE 2.2
## SOIL GAS CONCENTRATIONS MEASURED AT SITE PS-2
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

| Sample Location - Depth (feet bgs) [a/] | TVH (ppmv) [b/] | Benzene (ppmv) | Toluene (ppmv) | Ethylbenzene (ppmv) | Xylenes, Total (ppmv) |
|---|---|---|---|---|---|
| VW1 - 7.5 | 110,000 | 150 | < 3.7 | 24 | 130 |
| VMP1-4 | 78,000 | 160 | < 2.3 | 31 | 130 |
| VMP3-7 | 170,000 | 400 | 93 | 42 | 190 |

Source: ES, 1994.
Note: Soil gas analyzed according to EPA Method TO-3.
[a/] bgs = below ground surface.
[b/] TVH = total volatile hydrocarbons measured as jet fuel; ppmv = parts per million, volume per volume.



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TVH soil gas samples collected during initial soil gas measurements for the bioventing pilot test. The elevated concentrations of soil gas BTEX and TVH indirectly suggest the presence of soil contamination in the area immediately surrounding defueling pit 19. Analysis of discrete soil samples collected during the installation of the VW and VMPs for the bioventing pilot test confirmed the presence of elevated soil concentrations of total petroleum hydrocarbons (TPH) and BTEX compounds (ES, 1994).

#### 2.1.3.2 Soil Sampling and Analytical Results

Historical soil sampling data are available for sampling events that took place in 1986, 1988, 1990, 1991, 1993, and 1994. In 1986, 20 soil samples were collected from boreholes B-1 through B-10 at PS-2. Two years later, SAIC (1990)collected 6 additional soil samples during the installation of monitoring wells MW-55 and MW-56. In 1990, SAIC collected 8 additional soil samples during the installation of monitoring wells MW-105, MW-106, MW-109, and MW-110. In 1991, HNUS (1993) collected fifteen additional soil samples during the installation of soil borings 001 through 010. In 1993, ICF (1995) collected three soil samples during the installation of MW-229 and MW-230. Three additional samples were collected by ES (1994) in 1993 during the installation of the VW and VWPs for the bioventing pilot test. At a minimum, soil samples collected during these sampling events were analyzed for BTEX and TPH. Some soil sample were analyzed for additional contaminants; however, results reported for additional analytes are not of primary importance for completion of this TS and are not summarized in this work plan. Table 2.3 summarizes BTEX and TPH results for all soil samples collected during these sampling efforts. Locations of soil samples collected during the 1991 RI and the 1993 bioventing pilot test are shown on Figure 2.9. Locations and results of soil samples collected during the 1986, 1988, and 1990 SAIC investigations are presented on Figure 2.10.

Elevated BTEX and TPH concentrations were detected in several soil samples collected near defueling pit 19 and in one soil sample collected near defueling pit 18. Significant concentrations of BTEX and TPH in unsaturated soils appear to be limited to the soils in the vicinity of defueling pit 19. Vadose zone contamination at this location was detected by SAIC in 1986 and confirmed during the bioventing pilot test investigations in 1993. The maximum TPH concentration, 1,278 milligrams per kilogram (mg/kg), was measured in vadose soils during the 1986 investigation in borehole B-2 (SAIC, 1990). The maximum total BTEX contamination measured in unsaturated soils, 145.1 mg/kg, was detected during the 1993 bioventing pilot test investigation (ES, 1994) (Table 2.3). Unsaturated soil contamination in the region of defueling pit 18 is limited to isolated zones of TPH. A maximum TPH concentration of 180 mg/kg was detected by HNUS (1993) during the installation of borehole 5 in 1991. Soil sampling near MW-177 and MW-178 indicate that vadose soils in that area do not contain elevated concentrations of TPH or BTEX (HNUS, 1993). Notable concentrations of BTEX and TPH contamination appear to be limited to saturated soils immediately downgradient from defueling pit 19, and appear to coincide with areas of mobile LNAPL and elevated concentrations of BTEX and TPH in groundwater.

**TABLE 2.3**
**SUMMARY OF SOIL ANALYTICAL DATA FOR SITE PS-2**
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

| Soil Boring Identification | Sampling Event or Date | Depth (feet bgs)[c/] | Benzene (mg/kg)[d/] | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) | Total BTEX (mg/kg) | TPH[a/] (mg/kg) | TRPH[b/] (mg/kg) | TPH-diesel (mg/kg) | TPH-Jet Fuel (mg/kg) | Unknown Hydrocarbons (mg/kg) | Source[e/] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B-1 | 1986 | 2.5-4.0 | ND[f/] | 1.8 | 3.4 | 19.5 | 24.7 | ND | NA[g/] | NA | NA | NA | 1 |
| B-1 | 1986 | 5.0-5.5 | 2.4 | ND | 2.1 | 11.5 | 16 | 887 | NA | NA | NA | NA | 1 |
| B-2 | 1986 | 3.5-5.0 | ND | ND | 2.7 | 16.5 | 19.2 | 1278 | NA | NA | NA | NA | 1 |
| B-2 | 1986 | 3.5-5.0 | ND | ND | 2.1 | 8.9 | 11 | 525 | NA | NA | NA | NA | 1 |
| B-2 | 1986 | 5.0-6.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-3 | 1986 | 2.5-4.0 | ND | ND | 1.8 | 9.9 | 11.7 | 1151 | NA | NA | NA | NA | 1 |
| B-3 | 1986 | 4.0-5.5 | ND | 2.2 | 7.5 | 41.2 | 50.9 | 475 | NA | NA | NA | NA | 1 |
| B-4 | 1986 | 2.5-4.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-4 | 1986 | 8.5-10.5 | ND | 2.1 | ND | 14.1 | 16.2 | 126 | NA | NA | NA | NA | 1 |
| B-5 | 1986 | 4.0-5.5 | ND | ND | ND | ND | ND | 168 | NA | NA | NA | NA | 1 |
| B-5 | 1986 | 8.5-10.0 | ND | 9.4 | ND | 92.1 | 101.5 | 628 | NA | NA | NA | NA | 1 |
| B-6 | 1986 | 5.0-6.0 | ND | ND | ND | ND | ND | 370 | NA | NA | NA | NA | 1 |
| B-6 | 1986 | 10.0-10.75 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-7 | 1986 | 5.0-6.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-7 | 1986 | 8.0-9.5 | ND | 3.9 | 10.8 | 46.5 | 61.2 | 786 | NA | NA | NA | NA | 1 |
| B-8 | 1986 | 5.0-6.5 | ND | ND | ND | ND | ND | 466 | NA | NA | NA | NA | 1 |
| B-8 | 1986 | 8.0-9.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-9 | 1986 | 5.0-6.5 | ND | ND | ND | ND | ND | 238 | NA | NA | NA | NA | 1 |
| B-9 | 1986 | 5.0-6.5 | ND | ND | ND | ND | ND | 377 | NA | NA | NA | NA | 1 |
| B-9 | 1986 | 8.0-9.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-10 | 1986 | 5.0-6.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| B-10 | 1986 | 8.0-9.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| PS2-BH1 | 1988 | 3.0-3.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-55 | 1988 | 3.5-4.0 | ND | ND | ND | ND | ND | 13 | NA | NA | NA | NA | 1 |
| MW-55 | 1988 | 8.0-8.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-55 | 1988 | 13.0-13.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-56 | 1988 | 3.0-3.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-56 | 1988 | 8.0-8.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |

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## TABLE 2.3 (Continued)
## SUMMARY OF SOIL ANALYTICAL DATA FOR SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Soil Boring Identification | Sampling Event or Date | Depth (feet bgs)[c/] | Benzene (mg/kg)[d/] | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) | Total BTEX (mg/kg) | TPH[a/] (mg/kg) | TRPH[b/] (mg/kg) | TPH-diesel (mg/kg) | TPH-Jet Fuel (mg/kg) | Unknown Hydrocarbons (mg/kg) | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-56 | 1988 | 13.0-13.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-105 | 1990 | 7.0-8.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-106 | 1990 | 5.5-6.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-106 | 1990 | 10.5-11.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-106 | 1990 | 11.0-11.5 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-109 | 1990 | 6.0-6.5 | ND | ND | 1.0 | 3.2 | 4.2 | 460 | NA | NA | NA | NA | 1 |
| MW-109 | 1990 | 10.5-11.0 | ND | ND | ND | ND | ND | 170 | NA | NA | NA | NA | 1 |
| MW-110 | 190 | 5.5-6.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| MW-110 | 1990 | 10.5-11.0 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 001 | 1991 | 0-2 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 002 | 1991 | 2-6 | ND | ND | ND | 0.007 | 0.007 | ND | NA | NA | NA | NA | 1 |
| 002 | 1991 | 6-10 | ND | ND | ND | 0.014 | 0.014 | ND | NA | NA | NA | NA | 1 |
| 003 | 1991 | 0-2 | ND | ND | ND | ND | ND | NA | NA | NA | NA | NA | 1 |
| 003 | 1991 | 2-6 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 004 | 1991 | Composite | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 005 | 1991 | 0-2 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 005 | 1991 | 2-6 | ND | ND | ND | ND | ND | 180 | NA | NA | NA | NA | 1 |
| 006 | 1991 | 2-6 | 0.006 | ND | 0.005 | ND | 0.011 | ND | NA | NA | NA | NA | 1 |
| 006 | 1991 | 6-10 | ND | ND | 1.7 | 4.7 | 6.4 | ND | NA | NA | NA | NA | 1 |
| 007 | 1991 | Composite | ND | ND | ND | ND | ND | 1,200 | NA | NA | NA | NA | 1 |
| 008 | 1991 | 2-6 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 009 | 1991 | 0-2 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 009 | 1991 | 0-6 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| 010 | 1991 | 0-6 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| VW-1 | 1994 | 7.5 | 0.7 | 0.5 | 7.2 | 47 | 55.4 | NA | 250 | NA | NA | NA | 2 |
| VMP-1 | 1994 | 4 | 4.1 | ND | 21 | 120 | 145.1 | NA | 280 | NA | NA | NA | 2 |
| VMP-2 | 1994 | 4 | 0.14 | ND | 0.71 | 3.8 | 4.65 | NA | 980 | NA | NA | NA | 2 |

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## TABLE 2.3 (Concluded)
## SUMMARY OF SOIL ANALYTICAL DATA FOR SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Soil Boring Identification | Sampling Event or Date | Depth (feet bgs)[c] | Benzene (mg/kg)[d] | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) | Total BTEX (mg/kg) | TPH[a] (mg/kg) | TRPH[b] (mg/kg) | TPH-diesel (mg/kg) | TPH-Jet Fuel (mg/kg) | Unknown Hydrocarbons (mg/kg) | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-229 | 1994 | 5.5-6.0 | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | 3 |
| MW-229 | 1994 | 8.0-9.0 | ND | ND | ND | ND | ND | NA | NA | ND | ND | 850 | 3 |
| MW-230 | 1994 | 7.0-8.0 | ND | ND | ND | ND | ND | NA | NA | ND | ND | 800 | 3 |
| MW-230 | 1994 | 7.0-8.0 | ND | ND | ND | ND | ND | NA | NA | ND | ND | ND | 3 |

Notes:

[a] TPH = Total Petroleum Hydrocarbons

[b] TRPH = Total Recoverable Petroleum Hydrocarbons

[c] feet bgs = feet below ground surface

[d] mg/kg = milligrams per kilogram

[e] Sources:

1. HNUS, 1993
2. ES, 1994.
3. ICF, 1995.

[f] ND = Not detected.

[g] NA = Not analyzed.



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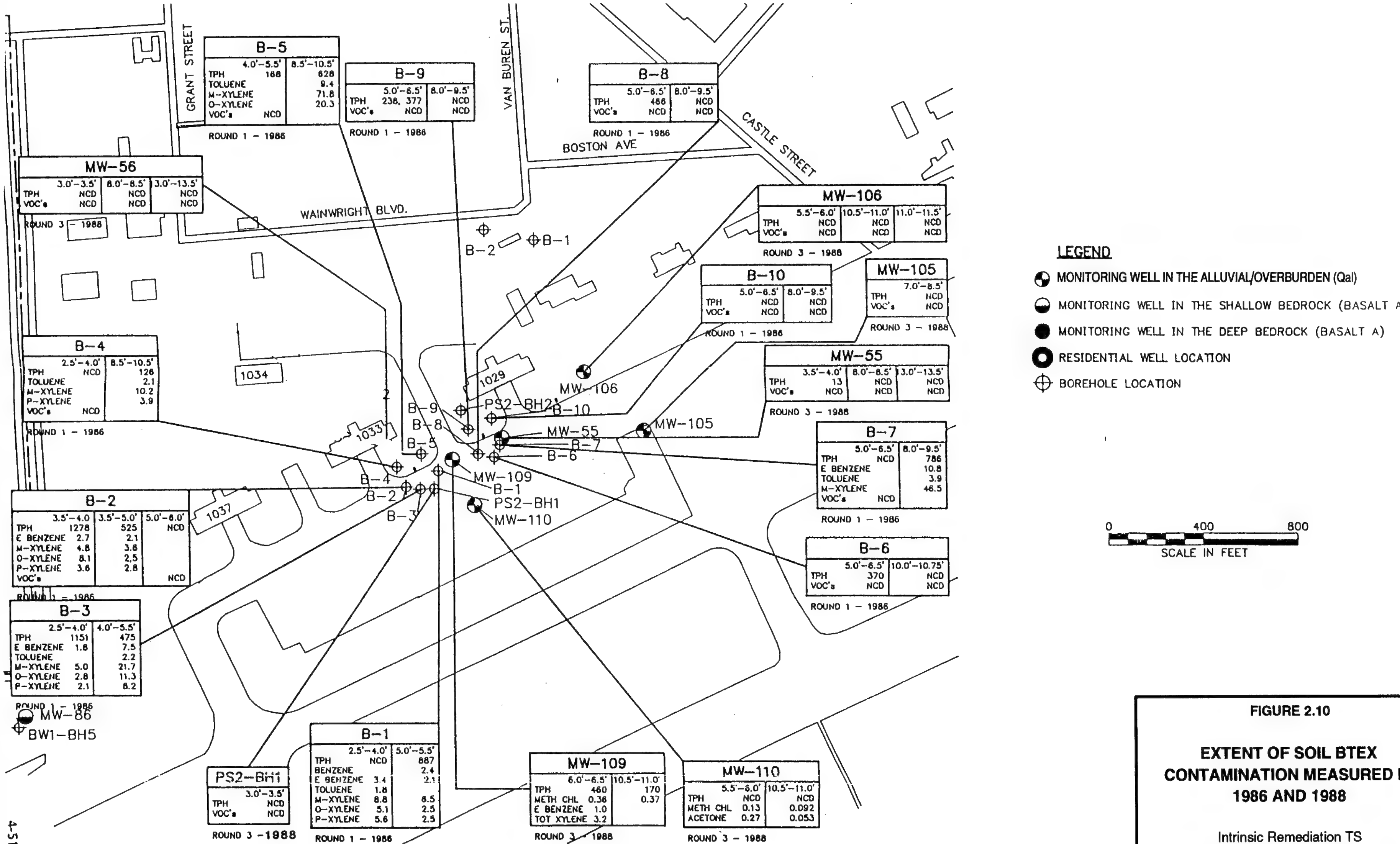


4-51

Sources: Halliburton NUS, 1993.

FIGURE 2.10

**EXTENT OF SOIL BTEX CONTAMINATION MEASURED IN 1986 AND 1988**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**

#### 2.1.3.3 Groundwater Sampling and Analytical Results

A total of 20 monitoring wells have been installed at PS-2. SAIC (1990) installed 2 wells (MW-55 and MW-56) in 1988, and four additional wells (MW-105, MW-106, MW-109, and MW-110) in 1990. Five wells (MW-176, MW-177, MW-178, MW-179, and MW-180) were installed during the RI in 1992 (HNUS, 1993). Limited information regarding installation of the floating free product recovery TS wells (MW-177A, MW-222, MW-223, MW-224, MW-228, MW-228A, and MW-228B) were available for inclusion in this work plan. However, it is believed that the Floating Fee Product TS wells were installed in 1993. Two additional monitoring wells (MW-229 and MW230) were installed in 1994 (ICF, 1995). Available well construction details are presented in Table 2.1. All of the monitoring wells at PS-2 are in front of Buildings 1029 and 1033 or adjacent to Taxiway No. 1 (Figure 2.11). Monitoring wells MW-178, MW-179, and MW-180 are screened in the shallow bedrock while all other monitoring wells are screened in the unconsolidated alluvial material.

Groundwater quality data have been collected from PS-2 wells on at least an annual basis since 1989 as part of long-term monitoring activities at the site. BTEX and TPH results for all site investigations and available ground water sampling events are presented in Table 2.4.

Mobile LNAPL at PS-2 has been observed near MW-176 and near MW-177 (Figure 2.11). Mobile LNAPL was first documented at PS-2 in MW-176 and MW-177 during the 1993 RI investigation. Product thicknesses in 1992 were 0.18 inch and 1.44 inches at MW-176 and MW-177, respectively (HNUS, 1993). The zones of the mobile LNAPL shown in Figure 2.11 appear to be physically and chemically different from each other. The LNAPL near MW-176 is amber in color, while the LNAPL collected from MW-177 is black (HNUS, 1993). Chemical analysis of the LNAPL present at the site was not been reported in available site investigation reports. However, groundwater samples collected from wells near MW-176 contained a significantly higher mass fraction of benzene than groundwater samples collected from wells near MW-177. This suggests that the two mobile LNAPL plumes are from two different sources, and that the product found in MW-177 is more weathered than the product found in MW-176. Additionally, mobile LNAPL was detected near defueling pit 19 during the installation of VMP-1 (ES, 1994). However, the thickness and physical characteristics of the free product detected at this location have not been documented.

Elevated concentrations of BTEX in groundwater correspond with regions of mobile LNAPL at PS-2 (Figures 2.11 and 2.12). Total BTEX concentrations in excess of 100 micrograms per liter (μg/L) were detected in groundwater samples collected from MW-177, MW-109, MW-176, MW-222, MW-224, MW-228 and MW-228A (Table 2.4). All of these sampling locations are within regions where mobile LNAPL has been observed. The leading edge of the BTEX plume appears to have higher concentrations of benzene than of the other BTEX compounds (Figure 2.13). This is consistent with theoretical predictions indicating that benzene is the most mobile of the other BTEX compounds.

Low BTEX concentrations have been detected in groundwater samples collected from MW-178, which is screened in the shallow bedrock. Although, early samples collected from MW-178 exhibited low concentrations of BTEX and TPH

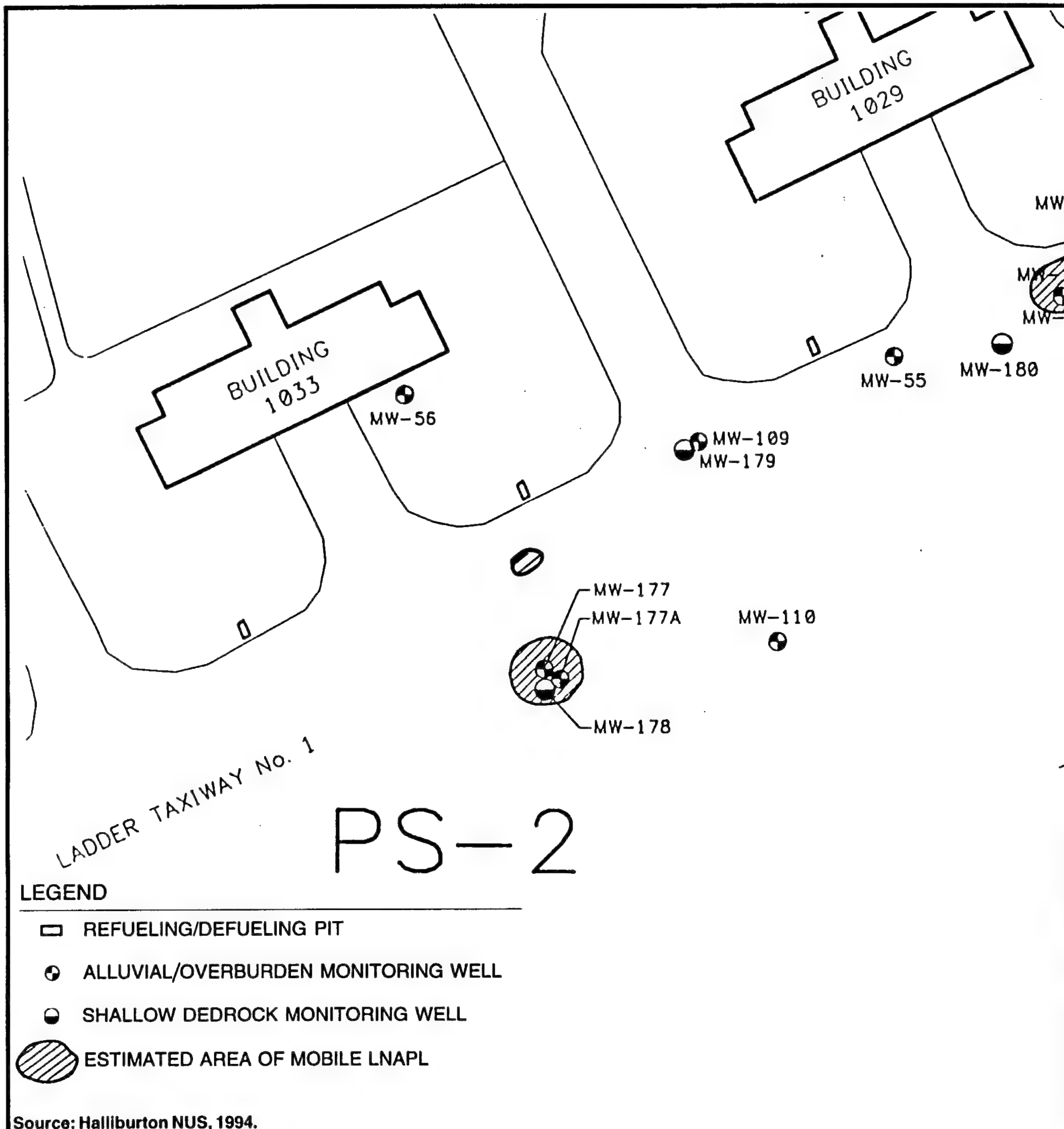


FIGURE 2.11

EXTENT OF MOBILE LNAPL AT PS-2

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

**TABLE 2.4**
**SUMMARY OF GROUNDWATER ANALYTICAL DATA FOR SITE PS-2**
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

| Location | Sampling Event or Date | Benzene (µg/L) [a] | Toluene (µg/L) | Ethylbenzene (µg/L) | Total Xylenes (µg/L) | Total BTEX (µg/L) | TPH (mg/L) [b] | TPH-gas (mg/L) | TPH-diesel (mg/L) | TPH-Jet Fuel (mg/L) | Unknown Hydrocarbons (mg/L) | Source [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-55 | 11/88 | 15 | ND [d] | 19 | 72 | 106 | 6.8 | NA [e] | NA | NA | NA | 1 |
| | 11/88 | 14 | ND | 21 | 72 | 107 | 0.6 | NA | NA | NA | NA | 1 |
| | 04/89 | 29 | ND | 35 | 150 | 214 | 0.6 | NA | NA | NA | NA | 1 |
| | 06/90 | 12 | ND | 12 | ND | 24 | 2 | NA | NA | NA | NA | 1 |
| | 08/90 | 53 | ND | 180 | 270 | 503 | ND | NA | NA | NA | NA | 1 |
| | 11/91 | 10.00 | ND | 13.00 | 25.00 | 48.00 | < 0.2 | NA | NA | NA | NA | 1 |
| | 11/91 | 41.00 | ND | 59.00 | 130.00 | 230.00 | 0.5 | NA | NA | NA | NA | 1 |
| | 08/94 | 20 | 5 U | 31 | 13 | 69 | NA | 0.89 J [f] | 0.20 | NA | NA | 4 |
| | 11/94 | 8 | 5 U [g] | 12 | 10 UJ [h] | 35 | NA | 0.12 | 0.25 U | NA | NA | 3 |
| | 11/94 | 11.0 | 1.0 U | 18 | 1.0 U | 31 | NA | NA | NA | NA | NA | 5 |
| | 11/94 | 10 | 1.0 U | 18 | 1.0 U | 30 | NA | NA | NA | NA | NA | 5 |
| | 04/95 | 16 | ND | 19 | 1.7 | 36.7 | NA | NA | NA | NA | NA | 2 |
| MW-56 | 11/88 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 04/89 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 06/90 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 08/90 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 11/91 | ND | ND | ND | ND | ND | < 0.2 | NA | NA | NA | NA | 1 |
| | 11/94 | 0.50 U | 1.0 U | 1.0 U | 1.0 U | 3.5 U | NA | NA | NA | NA | NA | 5 |
| | 11/94 | 0.50 U | 1.0 U | 1.0 U | 1.0 U | 3.5 U | NA | NA | NA | NA | NA | 5 |
| MW-105 | 02/91 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 04/91 | ND | ND | ND | ND | ND | < 0.20 | NA | NA | NA | NA | 1 |
| | 11/94 | 0.50 | 1.0 U | 1.0 U | 1.0 U | 3.5 | NA | NA | NA | NA | NA | 5 |

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## TABLE 2.4 (Continued)
## SUMMARY OF GROUNDWATER ANALYTICAL DATA FOR SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Location | Sampling Event or Date | Benzene (µg/L) [a] | Toluene (µg/L) | Ethylbenzene (µg/L) | Total Xylenes (µg/L) | Total BTEX (µg/L) | TPH (mg/L) [b] | TPH-gas (mg/L) | TPH-diesel (mg/L) | TPH-Jet Fuel (mg/L) | Unknown Hydrocarbons (mg/L) | Source [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-106 | 02/91 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 04/91 | ND | ND | ND | ND | ND | < 0.20 | NA | NA | NA | NA | 1 |
| | 11/91 | ND | ND | 5.00 | 12.00 | 17.00 | < 0.2 | NA | NA | NA | NA | 1 |
| MW-109 | 02/91 | 150 | ND | 530 | 1,200 | 1,880 | 16 | NA | NA | NA | NA | 1 |
| | 04/91 | 34 | ND | ND | 290 | 324 | 6.8 | NA | NA | NA | NA | 1 |
| | 11/91 | 40.00 J | ND | 190.00 J | 420.00 J | 650.00 J | 4.4 | NA | NA | NA | NA | 1 |
| | 11/91 | 40.00 | ND | 170.00 | 240.00 | 450.00 | 4.0 | NA | NA | NA | NA | 1 |
| | 11/94 | 12 | 5 U | 550 | 935 UJ | 1,502 | NA | 4.80 | 2.10 | NA | NA | 3 |
| | 11/94 | 10 U | 20 U | 530 | 780 | 1,340 | NA | NA | NA | NA | NA | 5 |
| | 11/94 | 10 U | 20 U | 380 | 670 | 1,080 | NA | NA | NA | NA | NA | 5 |
| | 04/95 | 23 | 2.2 | 160 | 224 | 409.2 | NA | NA | 3.9 | NA | NA | 2 |
| MW-109A | 04/95 | 21 | 1.2 | 120 | 152.6 | 294.8 | NA | NA | 5.3 | NA | NA | 2 |
| MW-110 | 02/91 | ND | ND | ND | ND | ND | ND | NA | NA | NA | NA | 1 |
| | 04/91 | ND | ND | ND | ND | ND | < 0.20 | NA | NA | NA | NA | 1 |
| | 08/94 | 5 U | 5 U | 5 U | 10 U | 25 U | NA | 0.26 J | 0.10 U | NA | NA | 4 |
| | 11/94 | 5 U | 5 U | 5 U | 10 U | 25 U | NA | 0.20 | 0.25 U | NA | NA | 3 |
| | 11/94 | 2.7 | 2.5 | 1.0 U | 26 | 32.2 | NA | NA | NA | NA | NA | 5 |
| | 11/94 | 1.8 | 1.3 | 1.0 U | 22 | 26.1 | NA | NA | NA | NA | NA | 5 |
| | 04/95 | 2.2 | ND | 3.0 | 1.0 | 6.2 | NA | NA | 0.72 | NA | NA | 2 |

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## TABLE 2.4 (Continued)
## SUMMARY OF GROUNDWATER ANALYTICAL DATA FOR SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Location | Sampling Event or Date | Benzene (µg/L) [a] | Toluene (µg/L) | Ethylbenzene (µg/L) | Total Xylenes (µg/L) | Total BTEX (µg/L) | TPH (mg/L) [b] | TPH-gas (mg/L) | TPH-diesel (mg/L) | TPH-Jet Fuel (mg/L) | Unknown Hydrocarbons (mg/L) | Source [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-176 | 11/91 | 2,600.00 | ND | 1,200.00 | 5,000.00 | 8,800.00 | 110 | NA | NA | NA | NA | 1 |
| | 08/94 | 1,200 | 2,500 | 580 | 4,500 | 8,780 | NA | 25.00 J | 100.00 | NA | NA | 4 |
| | 11/94 | 2,100 | 500 U | 2,400 | 11,500 | 16,500 | NA | 22.00 | 75.00 | NA | NA | 3 |
| MW-177 | 11/91 | 240.00 | ND | 520.00 | 2,200.00 | 2,960.00 | 27 | NA | NA | NA | NA | 1 |
| | 08/94 | 120 U | 120 U | 590 | 2,520 | 3,350 | NA | 11.00 J | 7.80 J | NA | NA | 4 |
| | 11/94 | 100 U | 100 U | 420 | 2,000 | 2,620 | NA | 11.00 | 13.00 J | NA | NA | 3 |
| MW-177A | 08/94 | 5 U | 5 U | 5 U | 10 U | 25 U | NA | 0.36 J | 0.10 U | NA | NA | 4 |
| | 08/94 | 5 U | 5 U | 5 U | 10 U | 25 U | NA | 0.55 J | 0.10 U | NA | NA | 4 |
| | 11/94 | 5 | 5 U | 5 U | 10 UJ | 25 | NA | 0.27 | 0.25 U | NA | NA | 3 |
| MW-178 | 11/91 | 7.00 | ND | 11.00 | 40.00 | 58.00 | < 0.2 | NA | NA | NA | NA | 1 |
| | 11/91 | 7.00 | ND | 10.00 | 38.00 | 55.00 | < 0.2 | NA | NA | NA | NA | 1 |
| | 11/94 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 4.0 U | NA | NA | NA | NA | NA | 5 |
| | 04/95 | ND | ND | ND | 1.3 | 1.3 | NA | NA | 0.27 | NA | NA | 2 |
| MW-179 | 11/94 | 1.0 U | 1.0 U | 1.0 U | 1.0 U | 4.0 U | NA | NA | NA | NA | NA | 5 |
| | 04/95 | NA | NA | NA | NA | NA | NA | NA | 0.27 | NA | NA | 2 |
| MW-180 | 11/91 | ND | ND | ND | ND | ND | < 0.2 | NA | NA | NA | NA | 1 |
| | 11/94 | 0.50 U | 1.0 U | 1.0 U | 1.0 U | 3.5 U | NA | NA | NA | NA | NA | 5 |
| | 04/95 | ND | ND | ND | 1.7 | 1.7 | NA | NA | NA | NA | NA | 2 |
| MW-222 | 08/94 | 44 | 5 U | 14 | 14 | 77 | NA | 6.905 | 1.00 | NA | NA | 4 |
| | 11/94 | 79 | 5 U | 26 | 10 U | 120 | NA | 8.50 | 0.38 | NA | NA | 3 |

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## TABLE 2.4 (Concluded)
## SUMMARY OF GROUNDWATER ANALYTICAL DATA FOR SITE PS-2
### INTRINSIC REMEDIATION TS
### FAIRCHILD AFB, WASHINGTON

| Location | Sampling Event or Date | Benzene (µg/L) [a] | Toluene (µg/L) | Ethylbenzene (µg/L) | Total Xylenes (µg/L) | Total BTEX (µg/L) | TPH (mg/L) [b] | TPH-gas (mg/L) | TPH-diesel (mg/L) | TPH-Jet Fuel (mg/L) | Unknown Hydrocarbons (mg/L) | Source [c] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-224 | 08/94 | 11 | 5 U | 94 | 43 | 153 | NA | 1.40 J | 0.83 J | NA | NA | 4 |
| | 11/94 | 52 | 5 U | 140 | 185 | 382 | NA | 1.90 | 1.10 | NA | NA | 3 |
| MW-228 | 08/94 | 220 | 120 U | 240 | 1,090 | 1,670 | NA | 25.00 J | 100.00 J | NA | NA | 4 |
| | 11/94 | 490 | 83 U | 420 | 2,083 | 3,076 | NA | 31.00 | 54.00 | NA | NA | 3 |
| MW-228A | 08/94 | 410 | 250 U | 430 | 2,250 | 3,340 | NA | 490.00 J | 190.00 J | NA | NA | 4 |
| | 11/94 | 2,000 | 250 U | 1,400 | 5,650 | 9,300 | NA | 45.00 | 110.00 | NA | NA | 3 |
| MW-228B | 08/94 | 67 | 5 U | 67 | 197 | 336 | NA | 1.60 J | 0.77 | NA | NA | 4 |
| | 08/94 | 66 | 5 U | 68 | 187 | 326 | NA | 2.10 J | 0.71 | NA | NA | 4 |
| | 11/94 | 28 J | 5 U | 22 J | 82 UJ | 137 UJ | NA | 1.30 | 0.40 | NA | NA | 3 |
| MW-229 | 11/94 | 3.2 | 3.9 | 21 | 7.4 | 35.5 | NA | NA | 0.50 U | 0.50 U | 0.87 | 5 |
| MW-230 | 11/94 | 0.50 U | 1.0 U | 2.7 | 1.0 U | 5.2 | NA | NA | 0.50 U | 0.50 U | 0.50 | 5 |
| | 11/94 | 0.50 U | 1.0 U | 3.7 | 1.0 U | 6.2 | NA | NA | 0.50 U | 0.50 U | 0.53 | 5 |

a/ µg/L = micrograms per liter.
b/ TPH = total petroleum hydrocarbons; mg/L = milligrams per liter.
c/ Sources:
1. HNUS, 1993.
2. ES&T AND MWA, 1995.
3. HNUS, 1995b.
4. HNUS, 1994.
5. ICF, 1995.
d/ ND = not detected.
e/ NA = not analyzed.
f/ J = estimated value.
h/ U = analyte not detected above method detection limit.
i/ UJ = estimated not detected.

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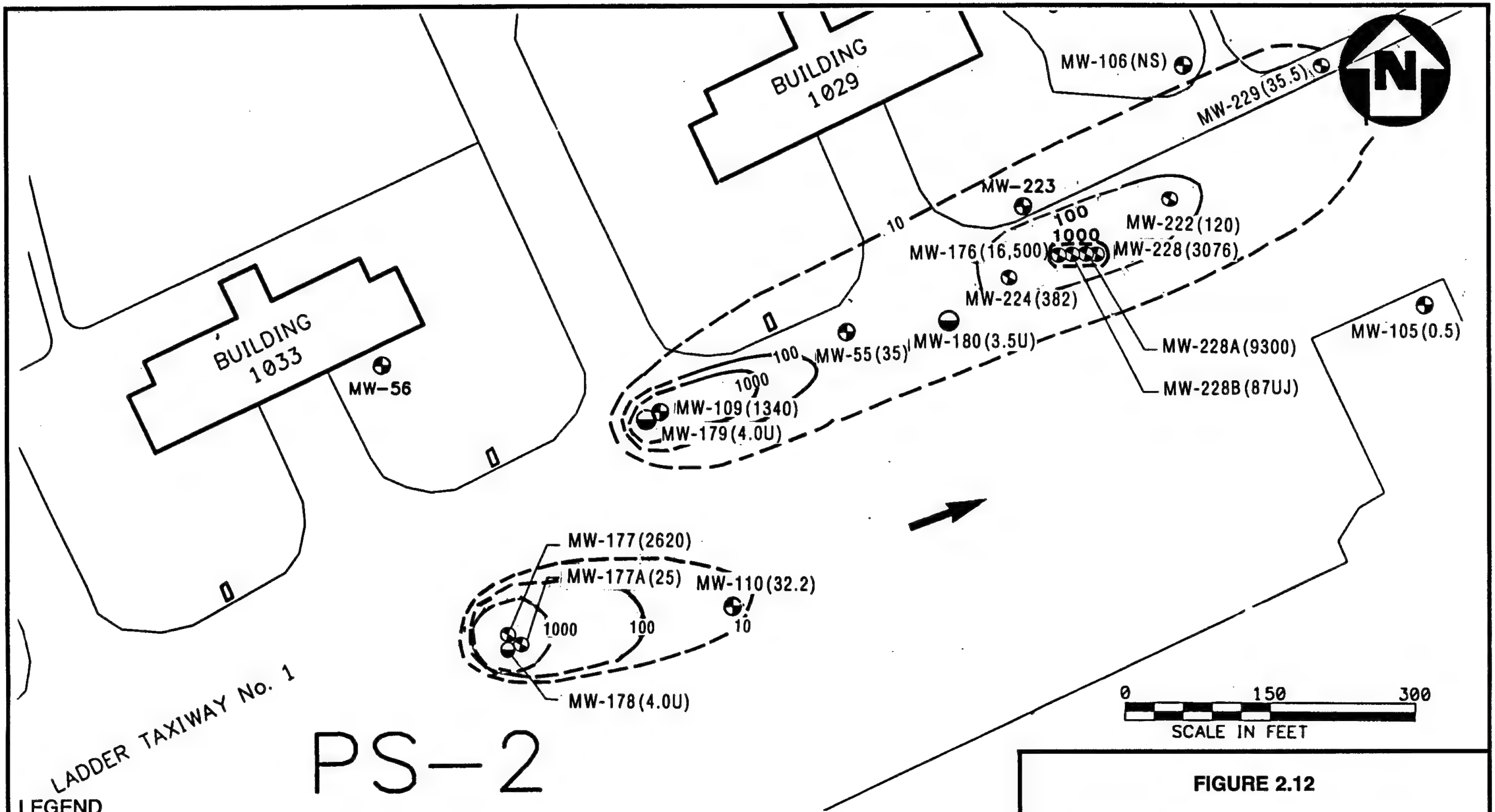



LEGEND

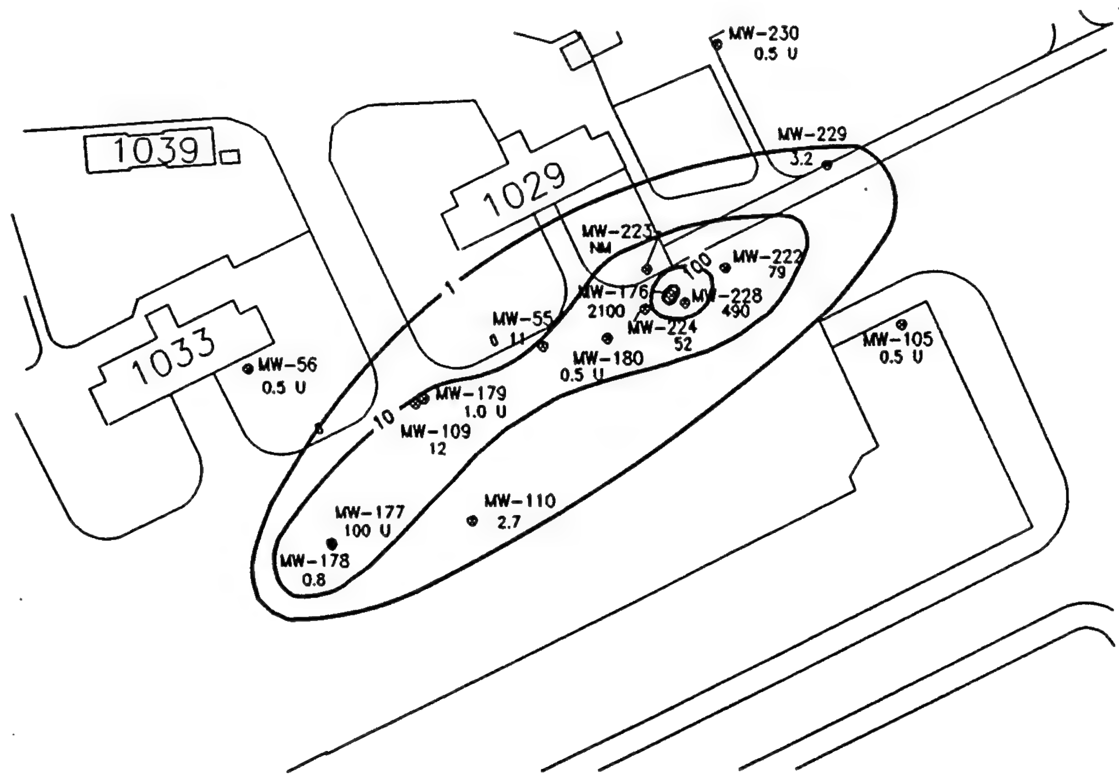
| | | | |
|---|---|---|---|
| ▭ | REFUELING/DEFUELING PIT | (25) | TOTAL BTEX CONCENTRATION (µg/l) |
| ⊕ | ALLUVIAL/OVERBURDEN MONITORING WELL | U | BTEX NOT DETECTED ABOVE MITHOD DETECTION LIMITS |
| ◒ | SHALLOW BEDROCK MONITORING WELL | J | ESTIMATED VALUE |
| — 100 — | ESTIMATED LINE OF EQUAL BTEX CONCENTRATION (µg/l) (DASHED WHEERRED). | NS | NOT SAMPLED |
| | | → | DIRECTION OF GROUNDWATER FLOW |

**FIGURE 2.12**

**EXTENT OF DISSOLVED TOTAL BTEX CONTAMINATION AT PS-2 NOVEMBER 1994**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado




LEGEND

| | |
|---|---|
| ▭ | BUILDINGS |
| ——— | ROADS |
| •MW-178 | ALLUVIAL WELLS |
| NM | NOT MEASURED |
| U | NON-DETECT, VALUE REPRESENTS DETECTION LIMIT |

CONCENTRATIONS IN ug/L

NOTE: DATA FROM EACH WELL IS FROM ITS MOST RECENT SAMPLING EVENT (SEE TABLE 4-4).

N

0 200 400
SCALE IN FEET

Sources: ICF Technology Inc., 1995.

**FIGURE 2.13**

**EXTENT OF BENZENE CONTAMINATION IN GROUNDWATER NOVEMBER, 1994**

Intrinsic Remediation TS
Fairchild AFB, Washington

**PARSONS ENGINEERING SCIENCE, INC.**
Denver, Colorado

contamination, more recent results of groundwater sampling at MW-178 indicate that BTEX contamination is declining at this location. BTEX and TPH have not been detected in groundwater samples collected from MW-179 or MW-180. Currently, no shallow bedrock wells have been installed beneath the body of free product detected near MW-176.

The data suggest that two separate and distinct dissolved BTEX plumes are present at PS-2. The two regions of mobile LNAPL detected at the site appear to be acting as continuing sources of BTEX contamination for the each of the dissolved BTEX plumes. Elevated concentrations of BTEX are not found in unsaturated soil samples collected above the dissolved BTEX plumes. Current analytical data also suggests that significant downward vertical migration in groundwater does not appear to be occurring at PS-2, although more data are required to confirm that such migration is not occurring near MW-176. Currently, the areal extents of the dissolved BTEX plumes at PS-2 are not fully delineated. Additional data will be necessary to fully delineate the dissolved plumes in the downgradient and crossgradient directions. Upgradient groundwater sampling also will be performed in order to measure geochemical data essential for evaluating intrinsic remediation at PS-2. Additionally, the poor correlation of reported source areas to current dissolved plume locations may require that more soil and groundwater data be collected to acquire a better understanding of plume dynamics.

## 2.2 DEVELOPMENT OF CONCEPTUAL SITE MODEL

A CSM is a three-dimensional representation of a site's hydrogeologic system based on available geological, hydrological, climatological, and geochemical data. A CSM is developed to provide an understanding of the mechanisms controlling contaminant fate and transport and to identify additional data requirements. The model describes known and suspected sources of contamination, types of contamination, affected media, and contaminant migration pathways. The model also provides a foundation for formulating decisions regarding additional data collection activities and potential remedial actions. The CSM for PS-2 will be used to aid in selecting additional data collection points and to identify appropriate data needs for modeling and hydrocarbon degradation using groundwater flow and solute transport models.

Successful conceptual model development involves:

- Defining the problem to be solved;
- Integrating available data, including
  - Local geologic and topographic data,
  - Hydraulic data,
  - Site stratigraphic data,
  - Contaminant concentration and distribution data;
- Evaluating contaminant fate and transport characteristics;

- Identifying contaminant migration pathways;
- Identifying potential receptor and receptor exposure points; and
- Determining additional data requirements.

### 2.2.1 Intrinsic Remediation and Groundwater Flow and Solute Transport Models

After a site has been adequately characterized, fate and transport analyses can be performed to determine the potential for contaminant migration and whether any pathway for exposure of human or ecological receptors to site contaminants may be complete. Groundwater flow and solute transport models have proven useful for predicting BTEX plume migration and contaminant attenuation by natural biodegradation. Analytical solute transport models and the Bioplume II numerical model (Rifai *et al.*, 1988) can be used to evaluate critical groundwater fate and transport processes that may be involved in some of the migration pathways to human and ecological receptors. Quantitative fate and transport analyses can be used to determine what level and extent of remediation is required.

An accurate estimate of the potential for natural biodegradation of BTEX compounds in groundwater is important to consider when determining whether fuel hydrocarbon contamination presents a substantial threat to human health and the environment, and when deciding what type of remedial alternative will be most cost-effective in eliminating or abating these threats. Over the past two decades, numerous laboratory and field studies have demonstrated that subsurface microorganisms can degrade a variety of hydrocarbons (Lee, 1988). This process occurs naturally when sufficient oxygen (or other electron acceptors) and nutrients are available in the groundwater. The rate of natural biodegradation is generally limited by the lack of oxygen (or other electron acceptors) rather than by the lack of nutrients such as nitrogen or phosphorus. The supply of oxygen to unsaturated soil is constantly renewed by the vertical diffusion from the atmosphere. The supply of oxygen to a shallow, fuel-contaminated aquifer is constantly renewed by the influx of oxygenated, upgradient flow and recharge from precipitation and by the vertical diffusion of oxygen from the unsaturated soil zone into the groundwater (Borden and Bedient, 1986). The rate of natural biodegradation in unsaturated soil and shallow aquifers is largely dependent upon the rates at which oxygen and other electron acceptors enter the contaminated media.

### 2.2.2 Biodegradation of Dissolved BTEX Contamination

The positive effect of natural attenuation processes (e.g., advection, dispersion, sorption, and biodegradation) on reducing the actual mass of fuel-related contamination dissolved in groundwater has been termed intrinsic remediation. Advantages of intrinsic remediation include: (1) contaminants are transformed to innocuous byproducts (e.g., carbon dioxide and water), not just transferred to another phase or location within the environment; (2) current pump-and-treat technologies are energy-intensive and generally not as effective in reducing residual contamination; (3) the process is nonintrusive and allows continuing use of infrastructure during remediation; (4) current engineered remedial technologies may pose a greater risk to potential receptors than intrinsic remediation because contaminants may be transferred into the

atmosphere during remediation activities; and (5) intrinsic remediation is far less costly than conventional, engineered remedial technologies.

To estimate the impact of natural attenuation on the fate and transport of BTEX compounds dissolved in groundwater at a site, two important lines of evidence must be demonstrated (Wiedemeier *et al.*, 1995). The first is a documented loss of contaminants at the field scale. Dissolved concentrations of biologically recalcitrant tracers found in most fuel contamination are used in conjunction with aquifer hydrogeologic parameters, such as groundwater seepage velocity and dilution, to demonstrate that a reduction in contaminant mass is occurring at the site. The second line of evidence involves the use of chemical analytical data in mass-balance calculations to show that areas with BTEX contamination can be correlated to areas with depleted electron acceptor (e.g., oxygen, nitrate, and sulfate) concentrations and increases in metabolic fuel degradation byproduct concentrations (e.g., methane and ferrous iron). With this site-specific information, groundwater flow and solute transport models can be used to simulate the fate and transport of dissolved BTEX compounds under the influence of natural attenuation.

Analytical and numerical models are available for modeling the fate and transport of fuel hydrocarbons under the influence of advection, dispersion, sorption, and natural aerobic and anaerobic biodegradation. Analytical models may be used in conjunction with the Bioplume II numerical model, as appropriate. The Bioplume II numerical model is based upon the USGS two-dimensional (2-D) solute transport model, which has been modified to include a biodegradation component that is activated by a superimposed plume of dissolved oxygen. Bioplume II solves the USGS 2-D solute equation twice, once for hydrocarbon concentrations in the groundwater and once for a dissolved oxygen plume. The two plumes are then combined using superimposition at every particle move to simulate biological reactions between fuel products and oxygen. As appropriate, biodegradation of contaminants by anaerobic processes is simulated using a first-order anaerobic decay rate.

The analytical solute transport models are derived from advection-dispersion equations given by Wexler (1992) and Van Genuchten and Alves (1982). These models provide exact, closed-form solutions and are appropriately used for relatively simple hydrogeologic systems that are homogeneous and isotropic. Each model is capable of simulating advection, dispersion, sorption, and biodegradation (or any first-order decay process). These models can simulate continuous or decaying sources. A continuous source model is useful for determination of the worst-case distribution of the dissolved contaminant plume. A decaying source model is useful for simulating source removal scenarios, including natural weathering processes and engineered solutions.

### 2.2.3 Initial Conceptual Site Model

Site PS-2 geologic data were previously integrated to produce two geologic cross-sections of the site. Cross sections A - A' and B - B' (Figures 2.6 and 2.7) show the dominant hydrostratigraphic units present at the site and the elevation of the water table. Figure 2.8 is a groundwater surface map prepared using October 1993 groundwater elevation data (ICF, 1995).

The surface of the groundwater table is present at approximately 6 to 9 feet bgs in the silty and gravelly sand, and gravel deposits in the vicinity of the site. Groundwater also occurs in shallow bedrock, which is present at 18 to 25 feet bgs. Groundwater flow in the alluvium is to the east-northeast, with an average gradient of 0.0045 ft/ft. On the basis of the available data, Parsons ES will model the site as an unconfined, fine- to coarse-grained sand and gravel aquifer. This CSM will be modified as necessary as additional site hydrogeologic data become available. Vertical migration of site contaminants in groundwater will be further investigated in the area of MW-176.

Mobile LNAPL is present at PS-2, and it will be necessary to use the fuel/water partitioning models of Bruce *et al.* (1991) or Cline *et al.* (1991) to provide a conservative source term to model the partitioning of BTEX from the mobile LNAPL into the groundwater. In order to use one of these models, samples of free product will be collected and analyzed for mass fraction of BTEX. Parsons ES also will collect additional groundwater samples from immediately below the LNAPL layer. Figure 2.11 shows the locations of the mobile LNAPL, and Figure 2.12 shows the extent of BTEX groundwater contamination at the site. Information from these maps and historical soil contamination data for the site (Table 2.3) will be used to select the locations of new monitoring wells to fully define the extents of the LNAPL and the dissolved BTEX plumes at PS-2.

Because of it solubility and relative toxicity benzene is the primary chemical of interest in groundwater at PS-2. However, the synergistic effects of all of the BTEX compound on attenuation rates make site data on all of the BTEX compounds important. Therefore, all of the BTEX compound will be the primary focus of this intrinsic remediation TS. The Bioplume II model will be used to simulate the degradation of these chemicals at PS-2 and to predict the concentrations and extent of the contaminant plumes in the groundwater over time.

Dissolved BTEX at the site are expected to leach from contaminated soils containing fuel residuals, to dissolve from mobile LNAPL into the groundwater, and to migrate downgradient as a dissolved contaminant plume. In addition to the effects of mass transport mechanisms (volatilization, dispersion, diffusion, and adsorption), these dissolved contaminants will likely be removed from the groundwater system by destructive attenuation mechanisms, such as biodegradation. The effects of these fate and transport processes on the dissolved groundwater plume will be investigated using the quantitative groundwater analytical data and the solute transport models. Data collection and analysis requirements are discussed in Section 3 of this work plan.

### 2.2.4 Potential Pathways and Receptors

Potential preferential contaminant migration pathways such as groundwater discharge points and subsurface utility corridors (artificial conduits) will be identified during the field work phase of this project. The primary potential migration path for contaminants at PS-2 is from the residual LNAPL in contaminated soils and mobile LNAPL at the site into the groundwater, and from the groundwater to potential receptors via ingestion or incidental contact.

Shallow groundwater beneath PS-2 flows toward the east-northeast. There are no known operating potable or nonpotable water wells (other than monitoring wells)

located within 1 mile downgradient or crossgradient from the site. Surface drainage by overland flow from the site is collected in the Base storm sewer network and transported to the wastewater lagoon in the southeastern corner of the Base. Surface soil contamination at the site is limited, and is not expected to impact surface water quality.

The potential for exposure to contaminated water originating from the site through ingestion is low because Base access is restricted and Base drinking water does not come from wells located downgradient from PS-2. There are residential areas that rely on domestic wells for drinking water near the eastern boundary of the Base. The closest known residential housing downgradient from the site is across Rambo Road adjacent to the eastern Base boundary, approximately 6,000 feet from the site. Site contaminants are not expected to migrate to these drinking water wells at concentrations exceeding regulatory levels intended to be protective of human health and the environment. However, the potential impacts on these wells will be of primary importance for assessing the feasibility of intrinsic remediation at PS-2 and will be considered in greater detail once additional site data essential for the evaluation of intrinsic remediation have been collected.

# SECTION 3

# COLLECTION OF ADDITIONAL DATA

To complete the TS and to demonstrate that intrinsic remediation of fuel-related contaminants is occurring, additional site-specific hydrogeologic data will be collected. The physical and chemical hydrogeologic parameters listed below will be determined during the field work phase of the TS.

Physical hydrogeologic characteristics to be determined include:

- Depth from measurement datum to the groundwater surface in site monitoring wells;
- Locations of potential groundwater preferential flow pathways and recharge and discharge areas;
- Locations of downgradient wells and their uses;
- Hydraulic conductivity through slug tests, as required;
- Estimate of dispersivity, where possible;
- Stratigraphic analysis of subsurface media;
- Groundwater temperature; and
- Determination of extent and thickness of mobile and residual LNAPL.

Chemical hydrogeologic characteristics to be determined include:

- Dissolved oxygen concentration;
- Specific conductance;
- pH;
- Chemical analysis of mobile LNAPL to determine mass fraction of BTEX; and
- Additional chemical analysis of groundwater and soil for the parameters listed in Table 3.1.

TABLE 3.1
ANALYTICAL PROTOCOL FOR PS-2
GROUNDWATER AND SOIL SAMPLES
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| MATRIX<br>Analyte | METHOD | FIELD (F) OR FIXED-BASE LABORATORY (L) |
|---|---|---|
| **WATER** | | |
| Total Iron | Colorimetric, HACH Method 8008 | F |
| Ferrous Iron ($Fe^{2+}$) | Colorimetric, HACH Method 8146 | F |
| Ferric Iron ($Fe^{3+}$) | Difference between total and ferrous iron | F |
| Manganese | Colorimetric, HACH Method 8034 | F |
| Sulfate | Colorimetric, HACH Method 8051 | F |
| Nitrate | Titrimetric, HACH Method 8039 | F |
| Nitrite | Titrimetric, HACH Method 8507 | F |
| Redox Potential | A2580B, direct reading meter | F |
| Oxygen | Direct reading meter | F |
| pH | E150.1/SW9040, direct reading meter | F |
| Conductivity | E120.1/SW9050, direct reading meter | F |
| Temperature | E170.1, direct reading meter | F |
| Carbon Dioxide | Titrimetric, HACH Method 1436-01 | F |
| Alkalinity (Carbonate [$CO_3^{2-}$] | F = Titrimetric, HACH Method 8221 | F |
| and Bicarbonate [HCO3- ]) | L = EPA method 310.1 | L |
| Nitrate + Nitrite | EPA Method 353.1 | L |
| Chloride | Waters Capillary Electrophoresis Method N-601 | L |
| Sulfate | Waters Capillary Electrophoresis Method N-601 | L |
| Methane, Ethane, Ethene | RSKSOP-147 | L |
| Dissolved Organic Carbon | RSKSOP-102 | L |
| Aromatic Hydrocarbons | RSKSOP-148 | L |
| Fuel Carbon | RSKSOP-148 | L |
| **SOIL** | | |
| Total Organic Carbon | RSKSOP-102 & RSKSOP-120 | L |
| Moisture | ASTM D-2216 | L |
| Aromatic Hydrocarbons | RSKSOP-124, modified | L |
| Total Hydrocarbons | RSKSOP-174 | L |
| **FREE PRODUCT** | | |
| BTEX Mass Fraction | GC/MS, Direct Injection | L |

In order to obtain these data, soil, groundwater, free product samples will be collected and analyzed. The following sections describe the procedures that will be followed when collecting additional site-specific data. Soil sampling and monitoring point installation will be accomplished using the Geoprobe® system as described in Sections 3.1 and 3.2. Soil core sample collection procedures are described in Section 3.1. Monitoring point installation procedures are described in Section 3.2. Groundwater sampling procedures for monitoring wells and newly installed groundwater monitoring points are described in Section 3.3. Measurement procedures for aquifer parameters (e.g., hydraulic conductivity) are described in Section 3.4.

## 3.1 SOIL SAMPLING

The following sections describe sampling locations, sample collection techniques, equipment decontamination procedures, site restoration, and management of investigation-derived waste materials.

### 3.1.1 Soil Sample Locations and Required Analyses

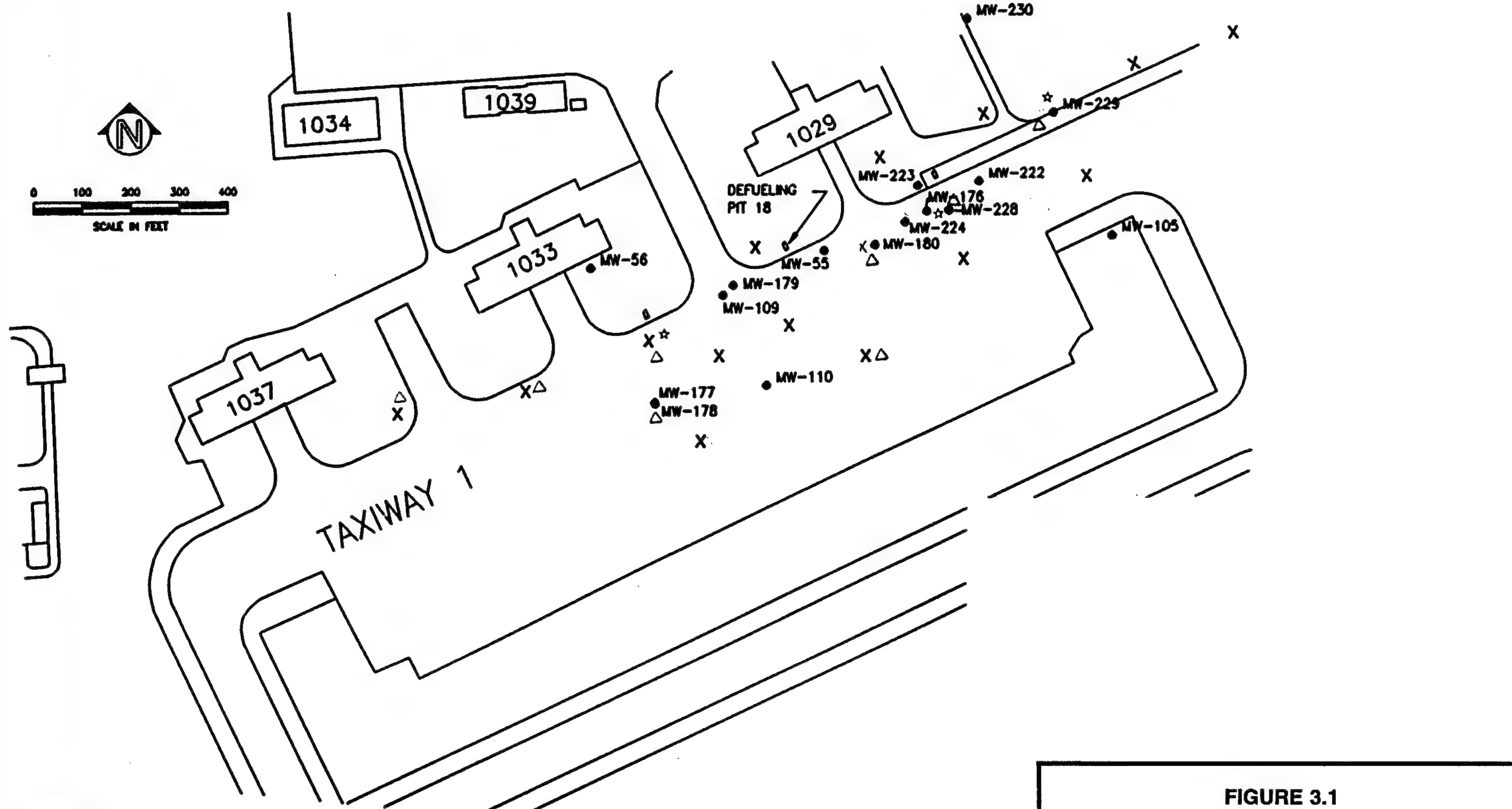
Soil samples will be collected at all Geoprobe® and monitoring point installation locations. Figure 3.1 identifies the proposed locations for soil sample collection at PS-2. Table 3.1 presents an analytical protocol for groundwater and soil samples, and Appendix A contains detailed information on the analyses and methods to be used during this sampling effort.

A minimum of two samples will be collected from each Geoprobe® hole location. One sample will be taken at the water table, and one will be taken at the depth of maximum BTEX contamination as determined by soil headspace screening. Sampling locations include suspected source areas in the vicinity of the monitoring well cluster MW-177/MW-178, monitoring well cluster MW-176/MW-228, and the bioventing system near defueling pit 19. Soil samples also will be collected from at least one location upgradient and downgradient from each of these suspected source areas. Additional samples will be collected at the discretion of the Parsons ES field scientist.

A portion of each sample will be used to measure soil headspace, and another portion of selected samples will be sent to the USEPA mobile laboratory for analytical analysis. Each laboratory soil sample will be placed in an analyte-appropriate sample container and hand-delivered to USEPA field personnel for analysis of total hydrocarbons, aromatic hydrocarbons, and moisture content using the procedures presented in Table 3.1. In addition, at least two samples will be analyzed for total organic carbon (TOC) from locations upgradient, crossgradient, or far downgradient from the contaminant source. Each headspace screening sample will be placed in a sealed plastic bag or mason jar and allowed to sit for at least 5 minutes. Volatile organic compounds (VOCs) in soil headspace will then be determined using an organic vapor meter (OVM), and the results will be recorded in the field records by the Parsons ES field scientist.

### 3.1.2 Sample Collection Using the Geoprobe® System

Soil samples will be collected using a Geoprobe® system, a hydraulically powered percussion/probing machine capable of advancing sampling tools through




LEGEND

MW-112 MONITORING WELL

X PROPOSED SHALLOW MONITORING POINT

☆ PROPOSED DEEP MONITORING POINT

△ PROPOSED GEOPROBE® SOIL SAMPLING LOCATION

Sources: ICF Technology Inc., 1995.

**FIGURE 3.1**

**PROPOSED SAMPLING AND MONITORING POINT LOCATIONS**

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unconsolidated soils. This system allows the rapid collection of soil, soil gas, and groundwater samples at shallow depths while minimizing the generation of investigation-derived waste materials. Figure 3.2 is a diagram of the Geoprobe® system.

Soil samples will be collected using a probe-drive sampler. The probe-drive sampler serves as both the driving point and the sample collection device and is attached to the leading end of the probe rods. To collect a soil sample, the sampler is pushed or driven to the desired sampling depth, the drive point is retracted to open the sampling barrel, and the sampler is subsequently pushed into the undisturbed soils. The soil cores are retained within brass, stainless steel, or clear acetate liners inside the sampling barrel. The probe rods are then retracted, bringing the sampling device to the surface. The soil sample can then be extruded from the liners for lithologic logging, or the liners can be capped and undisturbed samples can be submitted to the analytical laboratory for testing.

If the probe-drive sampling techniques described above are inappropriate, inadequate, or unable to efficiently provide sufficient soil samples for the characterization of the site, continuous soil samples will be obtained from conventional soil boreholes using a hand auger or similar method judged acceptable by the Parsons ES field scientist. Procedures will be modified, if necessary, to ensure good sample recovery.

The Parsons ES field scientist will be responsible for observing all field investigation activities, maintaining a detailed descriptive log of all subsurface materials recovered during soil coring, photographing representative samples, and properly labeling and storing samples. An example of the proposed geologic log form is presented in Figure 3.3. The descriptive log will contain:

- Sample interval (top and bottom depth);
- Sample recovery;
- Presence or absence of contamination;
- Lithologic description, including relative density, color, major textural constituents, minor constituents, porosity, relative moisture content, plasticity of fines, cohesiveness, grain size, structure or stratification, relative permeability, and any other significant observations; and
- Depths of lithologic contacts and/or significant textural changes measured and recorded to the nearest 0.1 foot.

Base personnel will be responsible for identifying the location of all utility lines, USTs, fuel lines, or any other underground infrastructure prior to any sampling activities. All necessary digging permits will be obtained by Base personnel prior to mobilizing to the field. Base personnel will also be responsible for acquiring drilling and monitoring point installation permits for the proposed locations. Because PS-2 is located on a part of the Base used by the National Guard, Base personnel will be

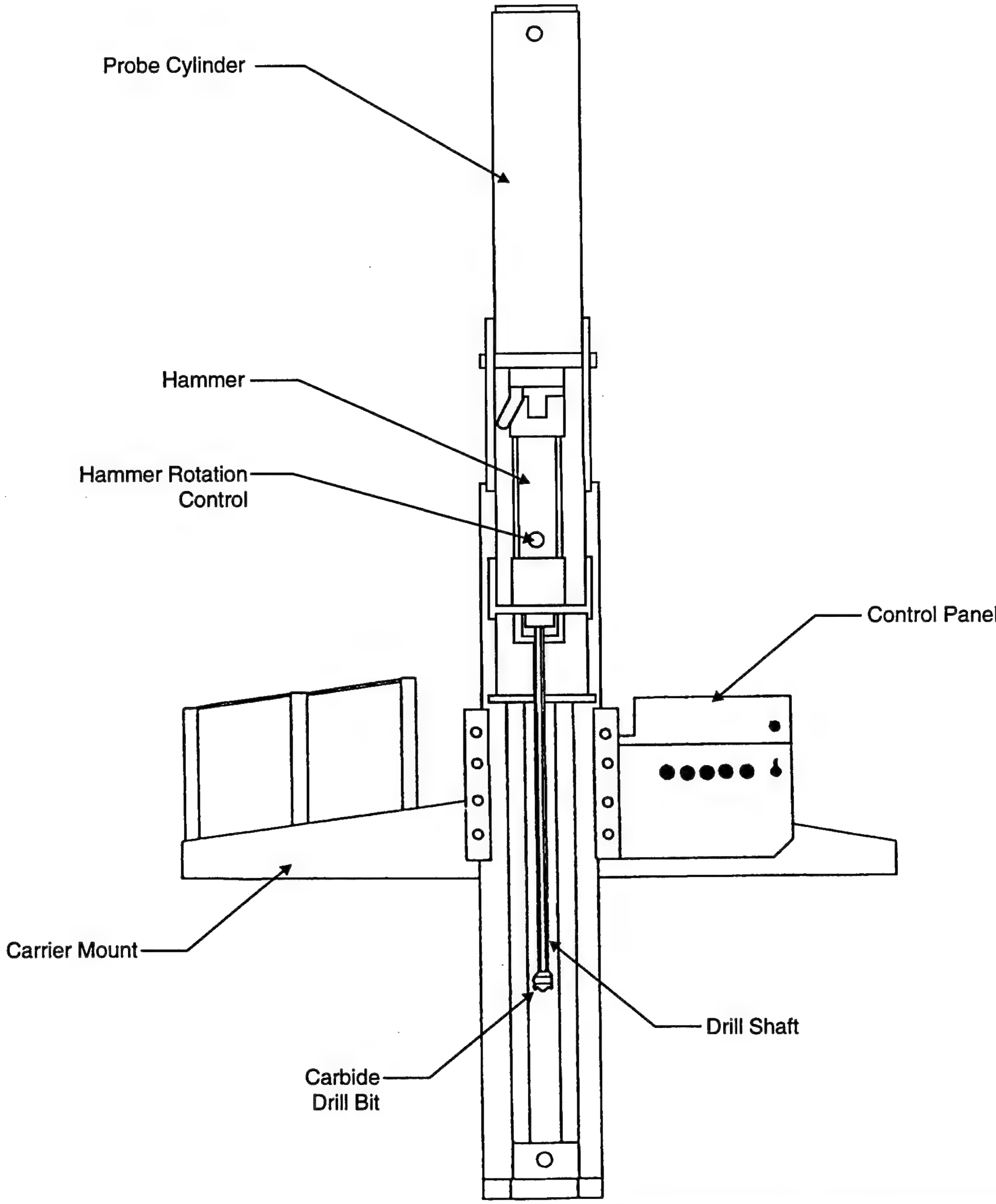


**Figure 3.2**

**CROSS SECTION OF GEOPROBE®**

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COREL/DRAW/GEOPROBE.CDR NAP 8/29/95 -TIF

# GEOLOGIC BORING LOG

BORING NO.: ______ CONTRACTOR: ______ DATE SPUD: ______
CLIENT: ______ RIG TYPE: ______ DATE CMPL.: ______
JOB NO.: ______ DRLG METHOD: ______ ELEVATION: ______
LOCATION: ______ BORING DIA.: ______ TEMP: ______
GEOLOGIST: ______ DRLG FLUID: ______ WEATHER: ______
COMENTS: ______

| Elev (ft) | Depth (ft) | Pro-file | US CS | Geologic Description | Sample No. | Sample Depth (ft) | Sample Type | Penet Res | PID(ppm) | TLV(ppm) | TOTAL BTEX(ppm) | TPH (ppm) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | | | | | | | | | | | |
| | 5 | | | | | | | | | | | |
| | 10 | | | | | | | | | | | |
| | 15 | | | | | | | | | | | |
| | 20 | | | | | | | | | | | |
| | 25 | | | | | | | | | | | |
| | 30 | | | | | | | | | | | |
| | 35 | | | | | | | | | | | |

NOTES

bgs – Below Ground Surface
GS – Ground Surface
TOC – Top of Casing
NS – Not Sampled
SAA – Same As Above

SAMPLE TYPE

D – DRIVE
C – CORE
G – GRAB

▼ Water level drilled

FIGURE 3.3

GEOLOGIC BORING LOG

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responsible for alerting appropriate WANG personnel of upcoming investigations. Parsons ES will be responsible for providing trained operators for the Geoprobe®.

### 3.1.3 Datum Survey

The horizontal location of all soil sampling locations relative to established Base coordinates will be measured by a surveyor. Horizontal coordinates will be measured to the nearest 0.1 foot. The elevation of the ground surface also will be measured to the nearest 0.1 foot relative to USGS msl data.

### 3.1.4 Site Restoration

After sampling is complete, each sampling location will be restored as closely to its original condition as possible. Holes created by the Geoprobe® in sandy soils similar to those found at the Base tend to cave in soon after extraction of the drive sampler. However, any test holes remaining open after extraction of the probe-drive will be sealed with hydrated bentonite chips, pellets, or grout to eliminate any creation or enhancement of contaminant migration pathways to the groundwater. Concrete will be used to top off holes punched through asphalt or concrete. The concrete plug will be flush with and at least as thick as the surrounding asphalt or concrete Soil sampling using the Geoprobe® creates low volumes of soil waste. Soil not used for sampling will be placed in 55-gallon drums, labeled, and transported to a Base-designated holding location while disposal is being arranged.

### 3.1.5 Equipment Decontamination Procedures

Prior to arriving at the site, and between each sampling location, probe rods, tips, sleeves, pushrods, samplers, tools, and other downhole equipment will be decontaminated using a high-pressure, steam/hot water wash or Alconox® wash with a potable water rinse. Between each soil sample, the sampling barrel will be disassembled and decontaminated with Alconox® and potable water. The barrel then will be rinsed with deionized water and reassembled with new liners. Between uses, the sampling barrel will be wrapped in clean plastic or foil to prevent contamination. Only potable water will be used for decontamination.

All rinseate will be collected in 55-gallon drums. Filled 55-gallon drums will be labeled and transported to a Base-designated holding location while disposal is being arranged. The Base will be responsible for signing required waste shipping and disposal manifests.

Potable water to be used during equipment cleaning, decontamination, or grouting will be obtained from one of the Base water supplies. Water use approval will be verified by contacting the appropriate facility personnel. The field scientist will make the final determination as to the suitability of site water for these activities. Precautions will be taken to minimize any impact to the surrounding area that might result from decontamination operations.

## 3.2 MONITORING POINT INSTALLATION

To further characterize site hydrogeologic conditions, up to 18 groundwater monitoring points may be installed at PS-2 to supplement the site monitoring wells. The following sections describe the proposed monitoring point locations and completion intervals, monitoring point installation, monitoring point development, and equipment decontamination procedures.

### 3.2.1 Monitoring Point Locations and Completion Intervals

The locations of 18 proposed groundwater monitoring points at PS-2 are identified on Figure 3.1. The proposed locations for the new monitoring points were determined from a review of data gathered during previous site activities. Monitoring point locations were selected to provide hydrogeologic data necessary for successful implementation of the Bioplume II model and to monitor potential fuel hydrocarbon migration from the site. Monitoring point locations were selected to define four aspects of the site: 1) the magnitude of the mobile LNAPL and dissolved BTEX concentrations within suspected source areas, 2) the extent of contamination, 3) the horizontal distribution of dissolved BTEX, and 4) the hydrogeology and groundwater flow direction at the site. The proposed locations shown on Figure 3.1 may be modified in the field as a result of encountered field conditions and acquired field data.

Three monitoring points will be installed in suspected source areas A shallow and deep monitoring point will be installed in the vicinity of VMP-1 near defueling pit 19. A single deep monitoring point will be installed in the area of mobile LNAPL associated with the monitoring wells MW-176, -228, -228A, and -228B. These points have the dual purpose of evaluating source area concentrations as well as the vertical extent of contamination within the source areas. Twelve shallow monitoring points are proposed to define the extent and configuration of the BTEX and mobile LNAPL plumes emanating from the suspected source areas. An additional two shallow monitoring points have been designated for areas upgradient from the dissolved BTEX plumes in order to evaluate background conditions at PS-2. A monitoring point screened near the bottom of the unconsolidated alluvium is proposed to be installed adjacent to monitoring well MW-229 in order to investigate the vertical extent of dissolved BTEX downgradient from the MW-176/228 source area. Because site conditions cannot always be predicted with complete accuracy prior to performance of the field work, two optional monitoring points have been reserved to further define the extent of contamination, the source areas, or the background site conditions.

Each shallow monitoring point will have a screened interval of approximately 3 feet placed near the top of the saturated zone. Deep monitoring points will be placed immediately above the bedrock basalt. The exact depth and location of monitoring points will be determined by the Parsons ES field scientist on the basis of site conditions. The proposed screened intervals of approximately 3 feet or less will help mitigate the dilution of water samples from potential vertical mixing of contaminated and uncontaminated groundwater in the monitoring point casing. Adjustments of the depth and length of the screened interval of the monitoring points may be necessary in response to actual aquifer conditions and contaminant distribution identified during Geoprobe® testing.

### 3.2.2 Monitoring Point Installation Procedures

#### 3.2.2.1 Pre-Placement Activities

All necessary digging, coring, and drilling permits will be obtained prior to mobilizing to the field. In addition, all utility lines will be located, and proposed Geoprobe® locations will be cleared prior to any intrusive activities. Responsibilities for these permits and clearances are discussed in Section 3.1.1.

Water to be used in monitoring point installation and equipment cleaning will be obtained from one of the Base water supplies. Water use approval will be verified by contacting the appropriate facility personnel. The field scientist will make the final determination as to the suitability of site water for these activities.

#### 3.2.2.2 Monitoring Point Materials Decontamination

Monitoring point installation and completion materials will be inspected by the field scientist and determined to be clean and acceptable prior to use. If not factory sealed, the well points and tubing will be cleaned prior to use with a high-pressure, steam/hot-water cleaner using approved water. Materials that cannot be cleaned to the satisfaction of the field scientist will not be used.

#### 3.2.2.3 Installation and Materials

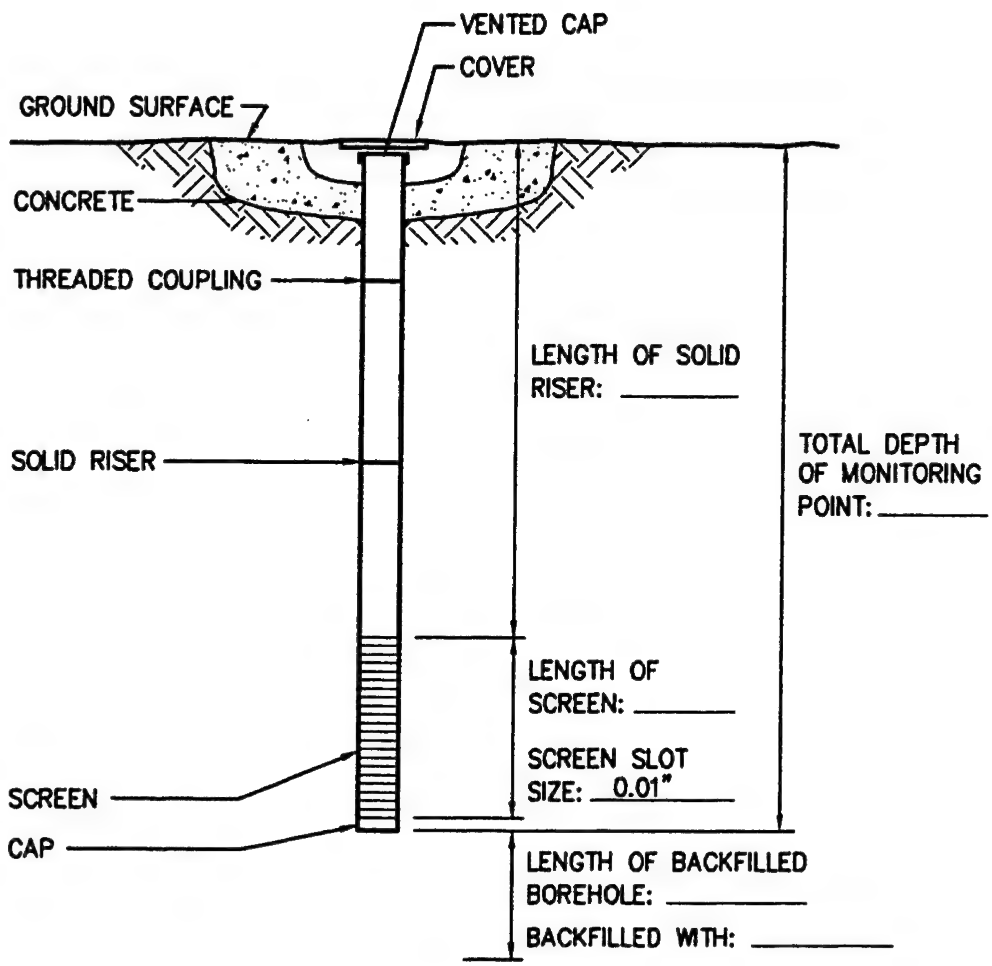
This section describes the procedures to be used for installation of monitoring points. Monitoring points will be installed using either 0.375-inch Teflon® tubing connected to a 0.5-inch-diameter stainless steel screen or a 0.5-inch inside-diameter (ID)/0.75-inch outside-diameter (OD) polyvinyl chloride (PVC) screen and casing.

If subsurface conditions permit, shallow monitoring points will be constructed of 0.75-inch OD-/0.5-inch-ID PVC casing and well screen to provide additional water level information. Approximately 3 feet of factory-slotted screen will be installed for each shallow monitoring point. Effective installation of the shallow monitoring points requires that the boreholes remain open upon completion of drilling. Shallow 0.5-inch-ID PVC monitoring points will be installed by punching and sampling a borehole with the Geoprobe®. Upon removing the rods, the borehole depth will be measured to determine if the hole remains open. If the borehole remains open, the 0.5-inch-ID PVC casing and screen will be placed at the appropriate depths. The annular space around the screen will be filled with sand filter pack, and the annulus around the casing will be filled with grout or bentonite. Monitoring point construction details will be noted on a Monitoring Point Installation Record form (Figure 3.4). This information will become part of the permanent field record for the site.

Monitoring point screens will be constructed of flush-threaded, Schedule 40 PVC with an ID of 0.5 inch. The screens will be factory slotted with 0.01-inch openings. Shallow monitoring point screens will be placed to sample and provide water level information at or near the water table. Blank monitoring point casing will be constructed of Schedule 40 PVC with an ID of 0.5 inch. All monitoring point casing sections will be flush-threaded; joints will not be glued. The casing at each monitoring point will be fitted with a bottom cap and a top cap constructed of PVC.

# MONITORING POINT INSTALLATION RECORD

JOB NAME ______ MONITORING POINT NUMBER ______
JOB NUMBER ______ INSTALLATION DATE ______ LOCATION ______
DATUM ELEVATION ______ GROUND SURFACE ELEVATION ______
DATUM FOR WATER LEVEL MEASUREMENT ______
SCREEN DIAMETER & MATERIAL ______ SLOT SIZE ______
RISER DIAMETER & MATERIAL ______ BOREHOLE DIAMETER ______
CONE PENETROMETER CONTRACTOR ______ ES REPRESENTATIVE ______




(NOT TO SCALE)

STABILIZED WATER LEVEL ______ FEET BELOW DATUM.

TOTAL MONITORING POINT DEPTH ______ FEET BELOW DATUM.

GROUND SURFACE ______ FEET

**FIGURE 3.4**

**MONITORING POINT INSTALLATION RECORD**

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If subsurface conditions do not permit the boreholes to remain open (i.e. the formation collapses in the hole), monitoring points will be constructed of a sacrificial drive point attached to a length of 0.5-inch-diameter stainless steel mesh that functions as the well screen, which in turn is connected to 0.375-inch Teflon® tubing. Holes are less likely to remain open for the installation of the deeper top-of-bedrock wells than the shallower top-of-water-table wells. To install tubing-cased monitoring points, the borehole is punched and sampled to several feet above the target depth for the monitoring point. The probe rods are withdrawn from the borehole, and the soil sampler is replaced with the well point assembly. An appropriate length of Teflon® tubing is threaded through the probe rods and attached to the well point. The assembly is lowered into the borehole and then driven down to the target depth and sampling zone. The probe rods are removed, leaving the sacrificial tip, screen assembly, and tubing behind. The soil is likely to cave in around the screen and tube assembly; where this does not occur, silica sand will be emplaced to create a sand pack around the well point, and the borehole annular space around the tubing above the sand pack will be filled with granular bentonite or grout to seal it. Monitoring point construction details will be noted on a Monitoring Point Installation Record form (Figure 3.4).

Should 0.5-inch-ID PVC shallow monitoring points not be installed, the only resulting data gap would be the lack of water level information for that particular location. The decision to install 0.5-inch-ID PVC monitoring points will be made in the field once the open-hole stability of subsurface soils and Geoprobe® equipment can be evaluated.

The field scientist will verify and record the total depth of the monitoring point, the lengths of all casing sections, and the depth to the top of all monitoring point completion materials. All lengths and depths will be measured to the nearest 0.1 foot.

#### 3.2.2.4 Monitoring Point Completion

Monitoring points will be completed at grade with the protective cover cemented in place using concrete blended into the existing pavement. Additional specifications for completion of monitoring points along the flight-line will be provided by 92 CES/CEVR personnel. Where pavement is not present, the protective cover will be raised slightly above the ground surface, with a 2-foot-square concrete pad that will slope gently away from the cover to facilitate runoff during precipitation events. After monitoring point completion, each site will be restored as closely as possible to its original condition.

### 3.2.3 Monitoring Point Development and Records

The new monitoring points will be developed prior to sampling to remove fine sediments from the portion of the formation adjacent to the screen. Development will be accomplished by lowering high density polyethylene (HDPE) tubing into the well or attaching Teflon® tubing to the pump lines and removing water with a peristaltic pump until pH, temperature, specific conductivity, and water clarity (turbidity) stabilize. At a minimum, 10 casing volumes of water will be developed from the monitoring point. In the event that 10 casing volumes of water cannot be recovered as a result of low water production, the water volume recovered and the deficiency will be noted in the

development records. Monitoring point development will occur a minimum of 24 hours prior to sampling.

A development record will be maintained for each new monitoring point. The development record will be completed in the field by the field scientist. Figure 3.5 is an example of a development record used for similar well installations. Development records will include:

- Monitoring point number;
- Date and time of development;
- Development method;
- Monitoring point depth;
- Volume of water produced;
- Description of water produced;
- Post-development water level and monitoring point depth (0.5-inch ID PVC monitoring points only); and
- Field analytical measurements, including pH and specific conductivity.

Development waters will be collected in 55-gallon drums. Filled 55-gallon drums will be labeled and transported to a Base-designated holding location while disposal is being arranged. The Base will be responsible for signing required shipping and disposal manifests.

### 3.2.4 Monitoring Point Location and Datum Survey

The location and elevation of the monitoring points will be surveyed by a registered surveyor soon after completion. Horizontal coordinates will be measured to the nearest 0.1 foot relative to established Base coordinates. The elevation of the flush-mount casing and measurement datum (top of interior casing) will be measured to the nearest 0.01 foot relative to USGS msl data.

### 3.2.5 Water Level Measurements

Water levels at all site monitoring points and wells will be measured within a short time period so that the water level data are comparable. The depth to water below the measurement datum will be measured to the nearest 0.01 foot using an electric water level probe or if mobile LNAPL is present an oil-water interface probe.

## 3.3 GROUNDWATER SAMPLING PROCEDURES

This section describes the scope of work required for collection of groundwater quality samples. Samples will be collected from previously installed monitoring wells and newly installed monitoring points. A peristaltic pump with dedicated HDPE tubing will be used to collect groundwater samples at monitoring points and wells. In order to maintain a high degree of QC during this sampling event, the procedures described in the following sections will be followed.

# MONITORING POINT DEVELOPMENT RECORD

Page__ of__

Job Number: 722450.18
Location: ____________________
Well Number____________________

Job Name: Fairchild AFB, Washington
By____________________ Date________
Measurement Datum____________________

Pre-Development Information

Time (Start):

Water Level:

Total Depth of Well:

Water Characteristics

Color____________________ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material____________________
pH__________ Temperature(oF oC) __________
Specific Conductance(μS/cm)____________________

Interim Water Characteristics

Gallons Removed

pH

Temperature (oF oC)

Specific Conductance(μS/cm)

Post-Development Information

Time (Finish):

Water Level:

Total Depth of Well:

Approximate Volume Removed:

Water Characteristics

Color____________________ Clear Cloudy
Odor: None Weak Moderate Strong
Any Films or Immiscible Material____________________
pH__________ Temperature(oF oC) __________
Specific Conductance(μS/cm)____________________

Comments:

**FIGURE 3.5**

**MONITORING POINT DEVELOPMENT RECORD**

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

Sampling will be conducted by qualified scientists and technicians from Parson ES and the USEPA RSKERL who are trained in the conduct of groundwater sampling, records documentation, and chain-of-custody procedures. In addition, sampling personnel will have thoroughly reviewed this work plan prior to sample acquisition and will have a copy of the work plan available onsite for reference. Groundwater sampling includes the following activities:

- Assembly and preparation of equipment and supplies;
- Inspection of the monitoring well/point integrity including:
  - Protective cover, cap, and lock,
  - External surface seal and pad,
  - Monitoring well/point stick-up, cap, and datum reference, and
  - Internal surface seal;
- Groundwater sampling, including:
  - Water level and product thickness measurements,
  - Visual inspection of sample water,
  - Monitoring well/point casing evacuation, and
  - Sample collection;
- Sample preservation and shipment, including:
  - Sample preparation,
  - Onsite measurement of physical parameters, and
  - Sample labeling;
- Completion of sampling records: and
- Sample disposition.

Detailed groundwater sampling and sample handling procedures are presented in following sections.

### 3.3.1 Preparation for Sampling

All equipment to be used for sampling will be assembled and properly cleaned and calibrated (if required) prior to arriving in the field. In addition, all record-keeping materials will be gathered prior to leaving the office.

#### 3.3.1.1 Equipment Cleaning

All portions of sampling and test equipment that will contact the sample matrix will be thoroughly cleaned before each use. This includes the split-spoon soil samplers, sampling pumps, water level probe and cable, test equipment for onsite use, and other equipment or portions thereof that will contact the samples. Given the types of sample analyses to be conducted, the following cleaning protocol will be used:

- Wash with potable water and phosphate-free laboratory detergent (HP-II detergent solutions, as appropriate);
- Rinse with potable water;
- Rinse with isopropyl alcohol;
- Rinse with distilled or deionized water; and
- Air dry.

Any deviations from these procedures will be documented in the field scientist's field notebook and on the groundwater sampling record (Figure 3.6).

If precleaned disposable sampling equipment is used, the cleaning protocol specified above will not be required. Laboratory-supplied sample containers will be cleaned and sealed by the laboratory. The type of container provided and the method of container decontamination will be documented in the USEPA mobile laboratory's permanent record of the sampling event.

#### 3.3.1.2 Equipment Calibration

As required, field analytical equipment will be calibrated according to the manufacturers' specifications prior to field use. This applies to equipment used for onsite measurements of dissolved oxygen (DO), pH, electrical conductivity, temperature, redox potential, sulfate, nitrate, ferrous iron ($Fe^{2+}$), and other field parameters listed on Table 3.1.

### 3.3.2 Sampling Procedures

Special care will be taken to prevent contamination of the groundwater and extracted samples. The primary ways in which sample contamination can occur is through contact with improperly cleaned sampling equipment. To prevent such contamination, the water level probe and cable used to determine static water levels and total well/point depths will be thoroughly cleaned before and after field use and between uses at different sampling locations according to the procedures presented in Section 3.3.1.1. Dedicated tubing will be used at each well/point developed, purged, and/or sampled with the peristaltic pump. In addition to the use of properly cleaned equipment, a clean pair of new, disposable nitrile or latex gloves will be worn each time a different monitoring point or well is sampled. The following paragraphs present the procedures to be followed for groundwater sample collection from groundwater monitoring points and wells. These activities will be performed in the order presented below. Exceptions to this procedure will be noted in the field scientist's field notebook or on the groundwater sampling record.

#### 3.3.2.1 Preparation of Location

Prior to starting the sampling procedure, the area around the monitoring points/wells will be cleared of foreign materials, such as brush, rocks, and debris. These procedures will prevent sampling equipment from inadvertently contacting debris around the monitoring point/well.

## GROUNDWATER SAMPLING RECORD

SAMPLING LOCATION ____________
SAMPLING DATE(S) ____________
MONITORING WELL ____________
(number)

REASON FOR SAMPLING: [ ] Regular Sampling; [ ] Special Sampling;
DATE AND TIME OF SAMPLING: ____________, 19___ ________ a.m./p.m.
SAMPLE COLLECTED BY: ____________ of ____________
WEATHER: ____________
DATUM FOR WATER DEPTH MEASUREMENT (Describe): ____________

MONITORING WELL CONDITION:
[ ] LOCKED: [ ] UNLOCKED
WELL NUMBER (IS - IS NOT) APPARENT
STEEL CASING CONDITION IS: ____________
INNER PVC CASING CONDITION IS: ____________
WATER DEPTH MEASUREMENT DATUM (IS - IS NOT) APPARENT
[ ] DEFICIENCIES CORRECTED BY SAMPLE COLLECTOR
[ ] MONITORING WELL REQUIRED REPAIR (describe): ____________

Check-off

1 [ ] EQUIPMENT CLEANED BEFORE USE WITH ____________
Items Cleaned (List): ____________

2 [ ] PRODUCT DEPTH ____________ FT. BELOW DATUM
Measured with: ____________

WATER DEPTH ____________ FT. BELOW DATUM
Measured with: ____________

3 [ ] WATER-CONDITION BEFORE WELL EVACUATION (Describe):
Appearance: ____________
Odor: ____________
Other Comments: ____________

4 [ ] WELL EVACUATION:
Method: ____________
Volume Removed: ____________
Observations: Water (slightly - very) cloudy
Water level (rose - fell - no change)
Water odors: ____________
Other comments: ____________

**FIGURE 3.6**

**GROUNDWATER SAMPLING RECORD**

Intrinsic Remediation TS
Fairchild AFB, Washington

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Denver, Colorado

## GROUND WATER SAMPLING RECORD (Continued)

MONITORING WELL ______________

5 [ ] SAMPLE EXTRACTION METHOD:

[ ] Bailer made of: ______________
[ ] Pump, type: _
[ ] Other, describe: ______________

Sample obtained is [ ] GRAB; [ ] COMPOSITE SAMPLE

6 [ ] ON-SITE MEASUREMENTS:

| | |
|---|---|
| Temp: ________ ° _____ | Measured with: ______________ |
| pH: ______________ | Measured with: ______________ |
| Conductivity: __________ | Measured with: ______________ |
| Dissolved Oxygen: __________ | Measured with: ______________ |
| Redox Potential: __________ | Measured with: ______________ |
| Salinity: __________ | Measured with: ______________ |
| Nitrate: __________ | Measured with: ______________ |
| Sulfate: __________ | Measured with: ______________ |
| Ferrous Iron: __________ | Measured with: ______________ |

Other: ______________

7 [ ] SAMPLE CONTAINERS (material, number, size): ______________

8 [ ] ON-SITE SAMPLE TREATMENT:

[ ] Filtration:

| | |
|---|---|
| Method ______________ | Containers: ______________ |
| Method ______________ | Containers: ______________ |
| Method ______________ | Containers: ______________ |

[ ] Preservatives added:

| | |
|---|---|
| Method ______________ | Containers: ______________ |
| Method ______________ | Containers: ______________ |
| Method ______________ | Containers: ______________ |
| Method ______________ | Containers: ______________ |

9 [ ] CONTAINER HANDLING:

[ ] Container Sides Labeled
[ ] Container Lids Taped
[ ] Containers Placed in Ice Chest

10 [ ] OTHER COMMENTS: ______________

**FIGURE 3.6 (Continued)**

**GROUNDWATER SAMPLING RECORD**

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

### 3.3.2.2 Water Level and Total Depth Measurements

Prior to removing water from the monitoring point/well, the static water level will be measured. An electric water level probe or oil/water interface probe will be used to measure the depth to groundwater below the datum to the nearest 0.01 foot. After measuring the static water level, the water level probe will be slowly lowered to the bottom of the monitoring point/well and the depth will be measured to the nearest 0.01 foot. If free-phase product (mobile LNAPL) is present, the total depth of the well from installation records will be used to avoid excessive contamination of the water level probe and cord. Based on these measurements, the volume of water to be purged from the monitoring point/well will be calculated. If mobile LNAPL is encountered, the thickness of the product will be measured with an oil/water interface probe.

### 3.3.2.3 Monitoring Point/Well Purging

The volume of water contained within the monitoring point/well casing at the time of sampling will be calculated, and at least three times the calculated volume will be removed from the well. A peristaltic pump will be used for monitoring point/well purging. All purge waters will be collected in 55-gallon drums. Filled 55-gallon drums will be labeled and transported to a Base-designated holding location while disposal is being arranged. The Base will be responsible for signing required shipping and disposal manifests.

If a monitoring point or well is evacuated to a dry state during purging, the point/well will be allowed to recharge, and the sample will be collected as soon as sufficient water is present in the monitoring point/well to obtain the necessary sample quantity. Sample compositing or sampling over a lengthy period by accumulating small volumes of water at different times to obtain a sample of sufficient volume will not be allowed.

### 3.3.2.4 Sample Extraction

Dedicated HDPE tubing and a peristaltic pump will be used to extract groundwater samples from monitoring points and wells. The tubing will be lowered through the casing into the water gently to prevent splashing. This step is omitted if the monitoring point is constructed of Teflon® tubing. The sample will be transferred directly into the appropriate sample container. The water will be carefully poured down the inner walls of the sample bottle to minimize aeration of the sample.

Unless other instructions are given by the USEPA mobile laboratory, sample containers will be completely filled so that no air space remains in the container. Excess water collected during sampling will be disposed of in the same manner as purge water.

### 3.3.3 Onsite Groundwater Parameter Measurement

As indicated on Table 3.1, many of the groundwater chemical parameters will be measured onsite by USEPA staff. Some of the measurements will be made with direct-reading meters, while others will be made using a HACH® portable colorimeter in

accordance with specific HACH® analytical procedures. These procedures are described in the following subsections.

All glassware or plasticware used in the analyses will have been cleaned prior to sample collection by thoroughly washing with a solution of laboratory-grade, phosphate-free detergent (e.g., Alconox®) and water, and rinsing with isopropyl alcohol and deionized water to prevent interference or cross-contamination between measurements. If concentrations of an analyte are above the range detectable by the titrimetric or colorimetric methods, the analysis will be repeated by diluting the groundwater sample with distilled water until the analyte concentration falls to a level within the range of the method. All rinseate and sample reagents accumulated during groundwater analysis will be collected in glass containers fitted with screw caps and properly disposed.

#### 3.3.3.1 Dissolved Oxygen Measurements

DO measurements will be made using a meter with a downhole oxygen sensor or a sensor in a flow-through cell before and immediately following groundwater sample acquisition. When DO measurements are taken in monitoring points/wells that have not yet been sampled, the monitoring points/wells will be purged until DO levels stabilize.

#### 3.3.3.2 pH, Temperature, and Specific Conductance

Because the pH, temperature, and specific conductance of a groundwater sample can change significantly within a short time following sample acquisition, these parameters will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made in a flow-through cell or a clean glass container separate from those intended for laboratory analysis, and the measured values will be recorded in the groundwater sampling record (Figure 3.6).

#### 3.3.3.3 Alkalinity Measurements

Alkalinity in groundwater helps buffer the groundwater system against acids generated through both aerobic and anaerobic biodegradation processes. Alkalinity of the groundwater sample will be measured in the field by experienced USEPA RSKERL scientists via titrimetric analysis using USEPA-approved HACH® Method 8221 (0 to 5,000 mg/L as calcium carbonate) or a similar method. Alkalinity of the groundwater sample also will be measured at the fixed-based laboratory using USEPA method 310.1.

#### 3.3.3.4 Nitrate- and Nitrite-Nitrogen Measurements

Nitrate-nitrogen concentrations are of interest because nitrate can act as an electron acceptor during hydrocarbon biodegradation under anaerobic soil or groundwater conditions. Nitrate-nitrogen is also a potential nitrogen source for biomass formation for hydrocarbon-degrading bacteria. Nitrite-nitrogen is an intermediate byproduct in both ammonia nitrification and in nitrate reduction in anaerobic environments.

Nitrate- and nitrite-nitrogen concentrations in groundwater will be measured in the field by experienced USEPA RSKERL scientists via colorimetric analysis using a HACH® DR/700 Portable Colorimeter. Nitrate concentrations in groundwater samples will be analyzed after preparation with HACH® Method 8039 (0 to 30.0 mg/L $NO_3$). Nitrite concentrations in groundwater samples will be analyzed after preparation with EPA-approved HACH® Method 8507 (0 to 0.35 mg/L $NO_2$) or a similar method.

#### 3.3.3.5 Carbon Dioxide Measurements

Carbon dioxide concentrations in groundwater will be measured in the field by USEPA RSKERL scientists via titrimetric analysis using HACH® Method 1436-01 (0 to 250 mg/L as $CO_2$). Sample preparation and disposal procedures are the same as outlined at the beginning of Section 3.3.3.

#### 3.3.3.6 Sulfate Measurements

Sulfate in groundwater is a potential electron acceptor for fuel-hydrocarbon biodegradation in anaerobic environments. A USEPA RSKERL scientist will measure sulfate concentrations via colorimetric analysis with a HACH® DR/700 Portable Colorimeter. After appropriate sample preparation. EPA-approved HACH® Method 8051 (0 to 70.0 mg/L $SO_4$) or similar will be used to prepare samples and analyze sulfate concentrations.

#### 3.3.3.7 Total Iron, Ferrous Iron, and Ferric Iron Measurements

Iron is an important trace nutrient for bacterial growth, and different states of iron can affect the redox potential of the groundwater and act as an electron acceptor for biological metabolism under anaerobic conditions. Iron concentrations will be measured in the field via colorimetric analysis with a HACH® DR/700 Portable Colorimeter after appropriate sample preparation. HACH® Method 8008 (or similar) for total soluble iron (0 to 3.0 mg/L $Fe^{3+}$ + $Fe^{2+}$) and HACH® Method 8146 (or similar) for ferrous iron (0 to 3.0 mg/L $Fe^{2+}$) will be used to prepare and quantitate the samples. Ferric iron will be quantitated by subtracting ferrous iron levels from total iron levels.

#### 3.3.3.8 Manganese Measurements

Manganese is a potential electron acceptor under anaerobic environments. Manganese concentrations will be quantitated in the field using colorimetric analysis with a HACH® DR/700 Portable Colorimeter. USEPA-approved HACH® Method 8034 (0 to 20.0 mg/L) or similar will be used for quantitation of manganese concentrations. Sample preparation and disposal procedures are outlined earlier in Section 3.3.3.

#### 3.3.3.9 Reduction/Oxidation Potential

The reduction/oxidation (redox) potential of groundwater is an indication of the relative tendency of a solution to accept or transfer electrons. Redox reactions in groundwater are usually biologically mediated; therefore, the redox potential of a groundwater system depends upon and influences rates of biodegradation. Redox potential can be used to provide real-time data on the location of the contaminant

plume, especially in areas undergoing anaerobic biodegradation. The redox potential of a groundwater sample taken inside the contaminant plume should be somewhat less than that taken in an upgradient location.

The redox potential of a groundwater sample can change significantly within a short time following sample acquisition and exposure to atmospheric oxygen. As a result, this parameter will be measured in the field in unfiltered, unpreserved, "fresh" water collected by the same technique as the samples taken for laboratory analyses. The measurements will be made as quickly as possible in a clean glass container separate from those intended for laboratory analysis or in a flow through cell.

## 3.4 SAMPLE HANDLING FOR LABORATORY ANALYSIS

This section describes the handling of samples from the time of sampling until the samples are delivered to USEPA field laboratory.

### 3.4.1 Sample Preservation

The USEPA mobile laboratory support personnel will add any necessary chemical preservatives prior to filling the sample containers. Samples will be prepared for transportation to the analytical laboratory by placing the samples in a cooler containing ice to maintain a shipping temperature of as close to 4 degrees centigrade (°C) as possible. Samples will be delivered promptly to USEPA field laboratory personnel, who will be responsible for shipment of appropriate samples to the RSKERL in Ada, Oklahoma for analysis.

### 3.4.2 Sample Container and Labels

Sample containers and appropriate container lids will be provided by the USEPA field laboratory (see Appendix A). The sample containers will be filled as described in Section 3.3.2.4, and the container lids will be tightly closed. The sample label will be firmly attached to the container side, and the following information will be legibly and indelibly written on the label:

- Facility name;
- Sample identification;
- Sample type (e.g., groundwater, soil);
- Sampling date;
- Sampling time;
- Preservatives added;
- Sample collector's initials; and
- Requested analyses.

### 3.4.3 Sample Shipment

After the samples are sealed and labeled, they will be packaged for transport to the onsite USEPA field laboratory. The following packaging and labeling procedures will be followed:

- Package sample so that it will not leak, spill, or vaporize from its container;
- Cushion samples to avoid breakage; and
- Add ice to container to keep samples cool.

The packaged samples will be delivered by hand to the USEPA field laboratory. Delivery will occur as soon as possible after sample acquisition.

### 3.4.4 Chain-of-Custody Control

Chain-of-custody documentation for the shipment of samples from the USEPA field laboratory to the RSKERL analytical laboratory in Ada, Oklahoma, will be the responsibility of the USEPA field personnel.

### 3.4.5 Sampling Records

In order to provide complete documentation of the sampling event, detailed records will be maintained by the field scientist. At a minimum, these records will include the following information:

- Sample location (facility name);
- Sample identification;
- Sample location map or detailed sketch;
- Date and time of sampling;
- Sampling method;
- Field observations of
  - Sample appearance, and
  - Sample odor;
- Weather conditions;
- Water level prior to purging (groundwater samples only);
- Total monitoring well/point depth (groundwater samples only);
- Sample depth (soil samples only);
- Purge volume (groundwater samples only);
- Water level after purging (groundwater samples only);
- Monitoring well/point condition (groundwater samples only);
- Sampler's identification;

- Field measurements of pH, temperature, DO, and specific conductivity (groundwater samples only); and
- Any other relevant information.

Groundwater sampling information will be recorded on a groundwater sampling form. Figure 3.6 shows an example of the groundwater sampling record. Soil sampling information will be recorded in the field log book.

### 3.4.6 Laboratory Analyses

Laboratory analyses will be performed on all groundwater and soil samples as well as the QA/QC samples described in Section 5. The analytical methods for this sampling event are listed in Table 3.1. Prior to sampling, USEPA RSKERL personnel will provide a sufficient number of analyte-appropriate sample containers for the samples to be collected. All containers, preservatives, and shipping requirements will be consistent with USEPA protocol or those reported in Appendix A of this plan.

USEPA laboratory support personnel will specify the necessary QC samples and prepare appropriate QC sample bottles. For samples requiring chemical preservation, preservatives will be added to containers by the laboratory. Containers, ice chests with adequate padding, and cooling media will be provided by USEPA RSKERL laboratory personnel. Sampling personnel will fill the sample containers and return the samples to the field laboratory.

## 3.5 AQUIFER TESTING

Slug tests will be conducted on selected monitoring wells to estimate the hydraulic conductivity of unconsolidated deposits at the site. This information is required to accurately estimate the velocity of groundwater and contaminants in the shallow saturated zone. A slug test is a single-well hydraulic test used to determine the hydraulic conductivity of an aquifer in the immediate vicinity of the tested well. Slug tests can be used for both confined and unconfined aquifers that have a transmissivity of less than 7,000 $ft^2$/day. Slug testing can be performed using either a rising head or a falling head test; at this site, both methods will be used in sequence.

### 3.5.1 Definitions

- **Hydraulic Conductivity (K)**. A quantitative measure of the ability of porous material to transmit water; defined as the volume of water that will flow through a unit cross-sectional area of porous or fractured material per unit time under a unit hydraulic gradient.
- **Transmissivity (T)**. A quantitative measure of the ability of an aquifer to transmit water. It is the product of the hydraulic conductivity and the saturated thickness.
- **Slug Test**. Two types of testing are possible: rising head and falling head tests. A slug test consists of adding a slug of water or a solid cylinder of known volume to the well to be tested or removing a known volume of water or cylinder and measuring the rate of recovery of water level inside the well. The slug of a known volume acts to raise or lower the water level in the well.

- **Rising Head Test**. A test used in an individual well within the saturated zone to estimate the hydraulic conductivity of the surrounding formation by lowering the water level in the well and measuring the rate of recovery of the water level. The water level may be lowered by pumping, bailing, or removing a submerged slug from the well.
- **Falling Head Test**. A test used in an individual well to estimate the hydraulic conductivity of the surrounding formation by raising the water level in the well by insertion of a slug or quantity of water, and then measuring the rate of drop in the water level.

### 3.5.2 Equipment

The following equipment will be used to conduct a slug test:

- Teflon®, PVC, or metal slugs;
- Nylon or polypropylene rope;
- Electric water level indicator;
- Pressure transducer/sensor;
- Field logbook/forms; and
- Automatic data recording instrument (such as the Hermit Environmental Data Logger®, In-Situ, Inc. Model SE1000B, or equivalent).

### 3.5.3 General Test Methods

Aquifer hydraulic conductivity tests (slug tests) are accomplished by either removal of a slug or quantity of water (rising head) or introduction of a slug (falling head), and then allowing the water level to stabilize while taking water level measurements at closely spaced time intervals.

Slug testing will proceed only after multiple water level measurements over time show that static water levels are in equilibrium. During the slug test, the water level change should be influenced only by the introduction (or removal) of the slug volume. Other factors, such as inadequate well development or extended pumping may lead to inaccurate results; in addition, slug tests will not be performed on wells with free product. The field scientist will determine when static equilibrium has been reached in the well. The pressure transducer, slugs, and any other downhole equipment will be decontaminated prior to and immediately after the performance of each slug test using the procedures described in Section 3.3.1.1.

### 3.5.4 Falling Head Test

The falling head test is the first step in the two-step slug testing procedure. The following steps describe procedures to be followed during performance of the falling head test.

1. Decontaminate all downhole equipment prior to initiating the test.

2. Open the well. Where wells are equipped with watertight caps, the well should be unsealed at least 24 hours prior to testing to allow the water level to stabilize. The protective casing will remain locked during this time to prevent vandalism.

3. Prepare the aquifer slug test data form (Figure 3.7) with entries for:

   - Borehole/well number,
   - Project number,
   - Project name,
   - Aquifer testing team,
   - Climatic data,
   - Ground surface elevation,
   - Top of well casing elevation,
   - Identification of measuring equipment being used,
   - Page number,
   - Static water level, and
   - Date.

4. Measure the static water level in the well to the nearest 0.01 foot.

5. Lower the decontaminated pressure transducer into the well and allow the displaced water to return to its static level. This can be determined by periodic water level measurements until the static water level in the well is within 0.01 foot of the original static water level.

6. Lower the decontaminated slug into the well to just above the water level in the well.

7. Turn on the data logger and quickly lower the slug below the water table, being careful not to disturb the pressure transducer. Follow the owner's manual for proper operation of the data logger.

8. Terminate data recording when the water level stabilizes in the well. The well will be considered stabilized for termination purposes when it has recovered 80 to 90 percent from the initial displacement.

# AQUIFER SLUG TEST DATA SHEET

Location: ______________________ Client: AFCEE Well No. ____________

Job No.: 722450.18 Field Scientist ____________ Date ____________

Water Level ______________________ Total Well Depth ______________________

Measuring Datum ______________________ Elevation of Datum ______________________

Weather ______________________ Temp ______________________

Comments ______________________________________________

______________________________________________

| Beginning Time | Ending Time | Initial Head Reading | Ending Head Reading | Test Type (Rise/Fall) | File Name | Comments |
|---|---|---|---|---|---|---|
| | | | | | | |
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**FIGURE 3.7**

**AQUIFER TEST DATA FORM**

Intrinsic Remediation TS
Fairchild AFB, Washington

PARSONS ENGINEERING SCIENCE, INC.
Denver, Colorado

### 3.5.5 Rising Head Test

After completion of the falling head test, the rising head test will be performed. The following steps describe the rising head slug test procedure.

1. Measure the water level in the well to the nearest 0.01 foot to ensure that it has returned to the static water level.

2. Initiate data recording and quickly withdraw the slug from the well. Follow the owner's manual for proper operation of the data logger.

3. Terminate data recording when the water level stabilizes in the well, and remove the pressure transducer from the well and decontaminate. The well will be considered stabilized for termination purposes when it has recovered 80 to 90 percent from the initial displacement.

### 3.5.6 Slug Test Data Analysis

Data obtained during slug testing will be analyzed using AQTESOLV™ and the method of Bouwer and Rice (1976) and Bouwer (1989) for unconfined aquifer conditions.

# SECTION 4

# REMEDIAL OPTION EVALUATION AND TS REPORT

Upon completion of field work, the Bioplume II numerical groundwater model will be used to determine the fate and transport of BTEX dissolved in groundwater at the site. On the basis of model predictions of contaminant concentration and distribution through time, and of potential receptors and exposure pathways, the potential for receptor to be exposed to BTEX concentrations above those intended to be protective of human health and the environment will be assessed. If it is shown that intrinsic remediation of BTEX compounds at the sites is sufficient to reduce the potential risk to human health and the environment to acceptable levels, Parsons ES will recommend implementation of the intrinsic remediation option. If intrinsic remediation is chosen, Parsons ES will prepare a site-specific, long-term monitoring plan that will specify the locations of point-of-compliance monitoring wells and sampling frequencies.

If the intrinsic remediation remedial option is deemed inappropriate for use at these sites, institutional controls such as groundwater or land use restrictions will be evaluated to determine if they will be sufficient to reduce the threat to human health and the environment to acceptable levels. If institutional controls are inappropriate, remedial options which could reduce risks to acceptable levels will be evaluated and the most appropriate remedial options will be recommended. Potential remedial options include, but are not limited to, bioslurping, groundwater pump-and-treat, enhanced biological treatment, bioventing, air sparging, and *in situ* reactive barrier walls. The reduction in dissolved BTEX that should result from remedial activities will be used to produce new input files for the groundwater models. The models will then be used to predict the BTEX source and plume (and risk) reduction that should result from remedial actions.

Upon completion of Bioplume II modeling and remedial option selection, a TS report detailing the results of the modeling and remedial option selection will be prepared. This report will follow the outline presented in Table 4.1 and will contain an introduction, site descriptions, identification of remediation objectives, description of remediation alternatives, an analysis of remediation alternatives, and the recommended remedial approach for each site. This report will also contain the results of the site characterization activities described herein and a description of the models developed for each site.

**TABLE 4.1**
**EXAMPLE TS REPORT OUTLINE**
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

---

INTRODUCTION
- Scope and Objectives
- Site Background

SITE CHARACTERIZATION ACTIVITIES
- Sampling and Aquifer Testing Procedures

PHYSICAL CHARACTERISTICS OF THE STUDY AREA
- Surface Features
- Regional Geology and Hydrogeology
- Site Geology and Hydrogeology
- Climatological Characteristics

NATURE AND EXTENT OF CONTAMINATION
- Source Characterization
- Soil Chemistry
  - Residual Contamination
  - Total Organic Carbon
- Groundwater Chemistry
  - LNAPL Contamination
  - Dissolved Contamination
  - Groundwater Geochemistry
  - Expressed Assimilative Capacity

GROUNDWATER MODEL
- Model Description
- Conceptual Model Design and Assumptions
- Initial Model Setup
- Model Calibration
- Sensitivity Analysis
- Model Results
- Conclusions

COMPARATIVE ANALYSIS OF REMEDIAL ALTERNATIVES
- Remedial Alternative Evaluation Criteria
  - Long-Term Effectiveness
  - Implementability (Technical, Administrative)
  - Cost (Capital, Operating, Present Worth)
- Factors Influencing Alternatives Development
  - Program Objectives
  - Contaminant Properties
  - Site-Specific Conditions
- Brief Description of Remedial Alternatives
  - Intrinsic Remediation with Long-Term Monitoring

**TABLE 4.1**
**EXAMPLE TS REPORT OUTLINE**
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

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Other Alternatives
Evaluation of Alternatives
Recommended Remedial Approach

LONG-TERM MONITORING PLAN
Overview
Monitoring Networks
Groundwater Sampling

CONCLUSIONS AND RECOMMENDATIONS

APPENDICES: Supporting Data and Documentation
Site-Specific Bioplume II Model Input and Results

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# SECTION 5

## QUALITY ASSURANCE/QUALITY CONTROL

Field QA/QC procedures will include collection of field duplicates and rinseate, field and trip blanks; decontamination of all equipment that contacts the sample medium before and after each use; use of analyte-appropriate containers; and chain-of-custody procedures for sample handling and tracking. All samples to be transferred to the mobile analytical laboratory for analysis will be clearly labeled to indicate sample number, location, matrix (e.g., groundwater), and analyses requested. Samples will be preserved in accordance with the analytical methods to be used, and water sample containers will be packaged in coolers with ice to maintain a temperature of as close to 4°C as possible.

All field sampling activities will be recorded in a bound, sequentially paginated field notebook in permanent ink. All sample collection entries will include the date, time, sample locations and numbers, notations of field observations, and the sampler's name and signature. Field QC samples will be collected in accordance with the program described below, and as summarized in Table 5.1.

QA/QC sampling will include collection and analysis of duplicate groundwater and soil samples, rinseate blanks, field/trip blanks, and matrix spike samples. Internal laboratory QC analyses will involve the analysis of laboratory control samples (LCSs) and laboratory method blanks (LMBs). QA/QC objectives for each of these samples, blanks, and spikes are described below.

Soil and groundwater samples collected with the Geoprobe® sampling tips should provide sufficient volume for some duplicate analyses. Refer to Appendix A for further details on sample volume requirements.

One rinseate sample will be collected for every 10 or fewer groundwater samples collected from existing wells. Because disposable bailers may be used for this sampling event, the rinseate sample will consist of a sample of distilled water poured into a new disposable bailer or run through a new set of pump tubing and subsequently transferred into a sample container provided by the laboratory. Rinseate samples will be analyzed for VOCs only.

A field blank will be collected for every 20 or fewer groundwater samples to assess the effects of ambient conditions in the field. The field blank will consist of a sample of distilled water poured into a laboratory-supplied sample container while sampling activities are underway. The field blank will be analyzed for VOCs.

**TABLE 5.1**
**QA/QC SAMPLING PROGRAM**
**INTRINSIC REMEDIATION TS**
**FAIRCHILD AFB, WASHINGTON**

| QA/QC Sample Types | Frequency to be Collected and/or Analyzed | Analytical Methods |
|---|---|---|
| Duplicates/Replicates | 3 Groundwater and 2 Soil Samples (10%) | VOCs, TPH |
| Rinseate Blanks | 2 Samples (5% of Groundwater Samples) | VOCs |
| Field Blanks | 2 Samples (5% of Groundwater Samples) | VOCs |
| Trip Blanks | One per shipping cooler containing VOC samples | VOCs |
| Matrix Spike Samples | Once per sampling event | VOCs |
| Laboratory Control Sample | Once per method per medium | Laboratory Control Charts (Method Specific) |
| Laboratory Method Blanks | Once per method per medium | Laboratory Control Charts (Method Specific) |

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A trip blank will be analyzed to assess the effects of ambient conditions on sampling results during the transportation of samples. The trip blank will be prepared by the laboratory. A trip blank will be transported inside each cooler which contains samples for VOC analysis. Trip blanks will be analyzed for VOCs.

Matrix spikes will be prepared in the laboratory and used to establish matrix effects for samples analyzed for VOCs.

LCSs and LMBs will be prepared internally by the laboratory and will be analyzed each day samples from the site are analyzed. Samples will be reanalyzed in cases where the LCS or LMB are out of the control limits. Control charts for LCSs and LMBs will be developed by the laboratory and monitored for the analytical methods used.

# SECTION 6

# REFERENCES


Battelle Laboratories, 1985, *National Perspective on Sediment Quality*. Prepared for USEPA, Criteria and Standards Division, EPA Contract No 68-01-6986.

Battelle Denver Operations, 1989, *Installation Restoration Program, IRP Phase II, Stage I Confirmation/Quantification, Fairchild AFB, Washington*. Prepared for the USAF, Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Borden, R.C., and Bedient, P.B. 1986. Transport of dissolved hydrocarbons influenced by oxygen limited biodegradation - theoretical development. *Water Resources Research,* vol. 22, no. 13. p. 1973-82.

Bouwer, H., 1989, The Bouwer and Rice slug test - an update: *Ground Water*, 27(3), p. 304-309.

Bouwer, H., and Rice, R.C., 1976, A slug test for determining hydraulic conductivity of unconfined aquifers with completely or partially penetrating wells: *Water Resources Research*, 12(3), p. 423-428.

Bruce, L., Miller, T., and Hockman, B., 1991, Solubility versus equilibrium saturation of gasoline compounds - a method to estimate fuel/water partition coefficient using solubility or $K_{OC}$... In, A. Stanley (editor), *NWWAI/API Conference on Petroleum Hydrocarbons in Ground Water*: NWT/API, p. 571-582.

Cline, D.R., 1969, *Groundwater Resources and Related Geology North-central Spokane and Southeastern Stevens Counties of Washington*. State of Washington Department of Water Resource Water Supply Bulletin, No. 27.

Cline, P.V., Delfino, J.J., and Rao, P.S.C., 1991, Partitioning of aromatic constituents into water from gasoline and other complex solvent mixtures: *Environmental Science and Technology*: v. 17, no. 4, p. 227-231.

EA Engineering, Science, and Technology and Montgomery Watson Americas, Inc. (ES&T and MWA), 1995, *Analytical Data Informal Technical Information Report: Long Term Monitoring -- April 1995 Sampling Craig Road Landfill and Priority 1 Sites SW-1, PS-2, PS-8, WW-1, FT-01, Fairchild AFB, Washington*. May.

Engineering-Science, Inc., (ES) 1993, *Health and Safety Plan for the Bioplume Modeling Initiative*. Prepared for the Air Force Center for Environmental Excellence, Environmental Restoration Division, USAF Contract F41624-92-D-8036.

ES, 1994, *Part I: Bioventing Pilot Test Work Plan for PS-2, PS-1A, PS-1B, Building 2034, Building 2035 and Part II: Draft Bioventing Pilot Test Interim Results Report for PS-2, PS-1A, PS-1B, Building 2034, Building 2035*. June.

Flint, R. I., 1936, *Stratified Drift and Deglaciation of Eastern Washington*. USGS Bulletin Vol. 47.

Halliburton NUS (HNUS), 1993, *Installation Restoration Program (IRP) Remedial Investigation Report Priority One Operable Units: LF-01 (SW-1); SD-05 (IS-1); SS-18 (PS-2); SS-28 (PS-6); SS-27 (PS-8); WP-03 (WW-1); FT-04 (FT-1), Fairchild AFB, Washington*. February.

HNUS, 1994a, Work Plan: Floating Free Product Passive Recovery Treatability Study, On-Base Priority One Operable Unit Flightline, Fairchild AFB, March.

HNUS, 1994b, Treatability Study Letter Report 07: Floating Free Product Passive Recovery Treatability Study, On-Base Priority One Operable Unit Flightline Operable Unit, Site PS-2, Fairchild AFB. December.

HNUS, 1995a, Treatability Study Letter Report 08: Floating Free Product Passive Recovery Treatability Study, On-Base Priority One Operable Unit Flightline Operable Unit, Site PS-2, Fairchild AFB. January.

HNUS, 1995b, Treatability Study Letter Report 09: Floating Free Product Passive Recovery Treatability Study, On-Base Priority One Operable Unit Flightline Operable Unit, Site PS-2, Fairchild AFB. January.

Hvorslev, M. J., 1951, *Time Lag and Soil Permeability in Ground-Water Observations:* United States Corps of Engineers Waterways Experiment Station Bulletin 36, Vicksburg, Mississippi. 50p.

ICF Technology, Inc. (ICF), 1995, *Long Term Monitoring Report for Priority 1 Sites SW-1 (LF-01), PS-2 (SS-18), and PS-8 (SS-26) at Fairchild AFB, Washington*. June.

JRB Associates, 1985, *Installation Restoration Program IRP Phase I Records Search, 92nd Bombardment Wing (Heavy) Fairchild AFB, Washington*. Prepared for the USAF, Occupational and Environmental Health Laboratory, Brooks AFB, Texas.

Konikow, L. F., and Bredehoeft, J. D., 1978, Computer model of two-dimensional solute transport and dispersion in ground water: United States Geological Survey, Techniques of Water Resources Investigations of the United States Geological Survey, Book 7, Chapter C2.

Lee, M.D. 1988. Biorestoration of aquifers contaminated with organic compounds. *CRC Critical Reviews in Environmental Control*, v. 18. p. 29-89.

Rifai, H.S., Bedient, P.B., Wilson, J.T., Miller, K.M., and Armstrong, J.M. 1988. Biodegradation modeling at aviation fuel spill site," *Journal of Environmental Engineering*, v. 114, no. 5, p. 1007-1029.

Science Applications International Corporation (SAIC), 1990, *Site Characterization Summary Priority One Sites*. December.

Theis, C. V., 1935, *The Relation Between the Lowering of the Piezometric Surface and the Rate and Duration of Discharge of a Well Using Groundwater Storage*. Trans. Amer. Geophys. Union, Vol. 16.

US Geological Survey (USGS), 1973a, 7.5 Minute Quadrangle Map of the Four Lakes Quadrangle, Washington.

USGS, 1973b, 7.5 Minute Quadrangle Map of the Medical Lake Quadrangle, Washington.

USGS, 1986a, 7.5 Minute Quadrangle Map of the Airway Heights Quadrangle, Washington.

USGS, 1986b, 7.5 Minute Quadrangle Map of the Deep Creek Quadrangle, Washington.

van Genuchten, M. T., and Alves, W. J., 1982, *Analytical Solutions of the One-Dimensional Convective-Dispersive Solute Transport Equation:* US Department of Agriculture, Technical Bulletin Number 1661, 151p.

Wexler, 1992, Analytical solutions for one-, two-, and three-dimensional solute transport in ground-water systems with uniform flow: *United States Geological Survey, Techniques of Water-Resources Investigations of the United States Geological Survey, Book 3,* Chapter B7, 190p.

Wiedemeier, Todd H., Downey, Douglas C., Wilson, John T., Kampbell, Donald H., Miller, Ross N., and Hansen, Jerry E., 1995, *Draft Technical Protocol for Implementing the Intrinsic Remediation (Natural Attenuation) with Long-term Monitoring Option for Dissolved-phase Fuel Contamination in Ground Water.* Prepared by the Air Force Center for Environmental Excellence.

# APPENDIX A

# CONTAINERS, PRESERVATIVES, PACKAGING, AND SHIPPING REQUIREMENTS FOR GROUNDWATER SAMPLES

# APPENDIX A

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Soil | Volatile organics | Gas chromatography/ mass spectrometry method SW8240. | Handbook method | Data is used to determine the extent of chlorinated solvent and aromatic hydrocarbon contamination, contaminant mass present, and the need for source removal | Each sampling round | Collect 100 g of soil in a glass container with Teflon®-lined cap; cool to 4°C | Fixed-base |
| Soil | Dehydrogenase enzyme activity (optional) | Colorimetric RSKSOP-100 | Reduction of added triphenyltetrazolium chloride by soil microbes is measured colorimetrically; analyze immediately | An indicator of the presence of soil microbes, which are necessary for bioremediation to occur | At the beginning of the project | Collect 100 g of soil in a glass container | Field |
| Soil | Aromatic hydrocarbons (benzene, toluene, ethyl-benzene, and xylene [BTEX]; trimethylbenzene isomers) | Purge and trap gas chromatography (GC) method SW8020 | Handbook method modified for field extraction of soil using methanol | Data is used to determine the extent of soil contamination, the contaminant mass present, and the need for source removal | Each sampling round | Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C | Fixed-base |
| Soil | Total hydrocarbons, volatile and extractable | GC method SW8015 [modified] | Handbook method; reference is the California LUFT manual | Data are used to determine the extent of soil contamination, the contaminant mass present, and the need for source removal | Each sampling round | Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C | Fixed-base |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Soil | Total organic carbon (TOC) | SW9060 modified for soil samples | Procedure must be accurate over the range of 0.5–15 percent TOC | Relatively high amounts of TOC may be indicative of a reducing environment and may indicate the need for analysis of electron acceptors associated with that environment; the rate of migration of petroleum contaminants in groundwater is dependent upon the amount of TOC in the saturated zone soil; the rate of release of petroleum contaminants from the source into groundwater is dependent (in part) on the amount of TOC in the vadose zone soil | At initial sampling | Collect 100 g of soil in a glass container with Teflon-lined cap; cool to 4°C | Fixed-base |
| Soil | Moisture | ASTM D-2216 | Handbook method | Data are used to correct soil sample analytical results for moisture content (e.g., report results on a dry weight basis) | Each soil sampling round | Use a portion of soil sample collected for another analysis | Fixed-base |
| Soil | Grain size distribution | ASTM D422 | Procedure provides a distribution of grain size by sieving | Data are used to infer hydraulic conductivity of aquifer, and are used in calculating sorption of contaminants | One time during life of project | Collect 250 g of soil in a glass or plastic container; preservation is unnecessary | Fixed-base |
| Soil gas | Carbon dioxide content of soil gas | Nondispersive infrared instrument operating over the range of approximately 0.1–15 percent | Soil gas carbon dioxide may be produced by the degradation of petroleum hydrocarbons | Data used to understand the carbon dioxide concentration gradient with depth and to infer the biological degradation of petroleum contaminants | Each sampling round | N/A | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Soil gas | Oxygen content of soil gas | Electrochemical oxygen meter operating over the range of 0–25 percent of oxygen in the soil gas sample | The concentration of soil gas oxygen is often related to the amount of biological activity, such as the degradation of petroleum hydrocarbons; soil gas oxygen concentrations may decrease to the point where anaerobic pathways dominate | Data are used to understand the oxygen concentration gradient with depth and to determine the presence or absence of aerobic degradation processes | Each sampling round | N/A | Field |
| Soil gas | Methane content of soil gas | Total combustible hydrocarbon meter using a platinum catalyst with a carbon trap, and operating in the low parts per million volume (ppmv) range | Methane is a product of the anaerobic degradation of petroleum hydrocarbons | Soil gas methane can be used to locate contaminated soil and to determine the presence of anaerobic processes; see discussion of data use for methane in water | Each sampling round | N/A | Field |
| Soil gas | Fuel hydrocarbon vapor content of soil gas | Total combustible hydrocarbon meter operating over a wide ppmv range | Soil gas hydrocarbons indicate the presence of these contaminants in the soil column | Data used to understand the petroleum hydrocarbon concentration gradient with depth and to locate the most heavily contaminated soils | Each sampling round | N/A | Field |
| Water | Ferrous ($Fe^{+2}$) | Colorimetric A3500-Fe D | Field only | May indicate an anaerobic degradation process due to depletion of oxygen, nitrate, and manganese | Each sampling round | Collect 100 ml of water in a glass container; acidify with hydrochloric acid per method | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Ferrous ($Fe^{+2}$) | Colorimetric HACH Method # 8146 | Alternate method; field only | Same as above | Each sampling round | Collect 100 ml of water in a glass container | Field |
| Water | Total Iron | Colorimetric HACH Method # 8008 | Field only | | Each sampling round | Collect 100mL of water in a glass container | Field |
| Water | Manganese | Colorimetric HACH Method # 8034 | Field only | | Each sampling round | Collect 100 mL of water in a glass container | Field |
| Water | Chloride | Mercuric nitrate titration A4500-$Cl^-$ C | Ion chromatography (IC) method E300 or method SW9050 may also be used | General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system | Each sampling round | Collect 250 mL of water in a glass container | Field |
| Water | Chloride | HACH Chloride test kit model 8-P | Silver nitrate titration | Same as above | Each sampling round | Collect 100mL of water in a glass container | Field |
| Water | Oxygen | Dissolved oxygen meter | Refer to method A4500 for a comparable laboratory procedure | The oxygen concentration is a data input to the Bioplume model; concentrations less than 1 mg/L generally indicate an anaerobic pathway | Each sampling round | Collect 300 mL of water in biochemical oxygen demand bottles; analyze immediately; alternately, measure dissolved oxygen *in situ* | Field |
| Water | Conductivity | E120.1/SW9050, direct reading meter | Protocols/Handbook methods | General water quality parameter used as a marker to verify that site samples are obtained from the same groundwater system | Each sampling round | Collect 100–250 mL of water in a glass or plastic container | Field |
| Water | Alkalinity | HACH Alkalinity test kit model AL AP MG-L | Phenolphthalein method | General water quality parameter used (1) as a marker to verify that all site samples are obtained from the same groundwater system and (2) to measure the buffering capacity of groundwater | Each sampling round | Collect 100mL of water in glass container | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Alkalinity | A2320, titrimetric; E310.2, colorimetric | Handbook method | Same as above | Each sampling round | Collect 250 mL of water in a glass or plastic container; analyze within 6 hours | Field |
| Water | Nitrate ($NO_3^{-1}$) | IC method E300 or method SW9056; colorimetric, method E353.2 | Method E300 is a Handbook method; method SW9056 is an equivalent procedure | Substrate for microbial respiration if oxygen is depleted | Each sampling round | Collect up to 40 mL of water in a glass or plastic container; cool to 4°C; analyze within 48 hours | Fixed-base |
| Water | Nitrate ($NO_3^{-1}$) | HACH method # 8039 for high range method # 8192 for low range | Colorimetric | Same as above | Each sampling round | Collect 100mL of water in a glass container | Field |
| Water | Nitrite (NO | HACH method #8040 | Colorimetric | Substrate for microbial respiration if oxygen is depleted | Each sampling round | Collect 100mL of water in a glass container | Field |
| Water | Sulfate ($SO_4^{-2}$) | IC method E300 or method SW9056 | Method E300 is a Handbook method; method SW9056 is an equivalent procedure | Substrate for anaerobic microbial respiration | Each sampling round | Collect up to 40 mL of water in a glass or plastic container; cool to 4°C | Fixed-base |
| Water | Sulfate ($SO_4^{-2}$) | HACH method # 8051 | Colorimetric | Same as above | Each sampling round | Collect up to 40 mL of water in a glass or plastic container; cool to 4°C | Field |
| Water | Dissolved sulfide ($S^{-2}$) | HACH method # 8131 | Colorimetric | Product of sulfate-based anaerobic microbial respiration; analyze in conjunction with sulfate analysis | Each sampling round | Collect 100 mL of water in a glass container; analyze immediately | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Ethane, ethene | RSKSOP-114 (cont'd) | Ethane and ethene are analyzed in addition to the other analytes only if chlorinated hydrocarbons are contaminants suspected of undergoing biological transformation | Ethane and ethene are products of the bio-transformation of chlorinated hydrocarbons under anaerobic conditions. The presence of these chemicals may indicate that anaerobic degradation is occurring | | | |
| Water | Carbon dioxide | HACH test kit model CA-23 or CHEMetrics Method 4500 | Titrimetric; alternate method | The presence of free carbon dioxide dissolved in groundwater is unlikely because of the carbonate buffering system of water, but if detected, the carbon dioxide concentrations should be compared with background to determine whether they are elevated; elevated concentrations of carbon dioxide could indicate an aerobic mechanism for bacterial degradation of petroleum | Each sampling round | Collect 100 mL of water in a glass container | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Aromatic hydrocarbons (BTEX, trimethylbenzene isomers) | Purge and trap GC method SW8020 | Handbook method; analysis may be extended to higher molecular weight alkyl benzenes | Method of analysis for BTEX, which is the primary target analyte for monitoring natural attenuation; BTEX concentrations must also be measured for regulatory compliance; method can be extended to higher molecular weight alkyl benzenes; trimethylbenzenes are used to monitor plume dilution if degradation is primarily anaerobic | Each sampling round | Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2 | Fixed-base |
| Water | Total hydrocarbons, volatile and extractable | GC method SW8015 [modified] | Handbook method; reference is the California LUFT manual | Data used to monitor the reduction in concentrations of total fuel hydrocarbons (in addition to BTEX) due to natural attenuation; data also used to infer presence of an emulsion or surface layer of petroleum in water sample, as a result of sampling | One time per year or as required by regulations | Volatile hydrocarbons–collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2<br>Extractable hydrocarbons–collect 1 L of water in a glass container; cool to 4°C; add hydrochloric acid to pH 2 | Fixed-base |
| Water | Polycyclic aromatic hydrocarbons (PAHs) (optional) | GC/mass spectroscopy method SW8270; high-performance liquid chromatography method SW8310 | Analysis needed only for several samples per site | PAHs are components of fuel and are typically analyzed for regulatory compliance; data on their concentrations are not used currently in the evaluation of natural attenuation | At initial sampling and at site closure or as required by regulations | Collect 1 L of water in a glass container; cool to 4°C | Fixed-base |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Total fuel carbon (optional) | Purge and trap GC method SW8020 modified to measure all volatile aromatic hydrocarbons present in the sample | A substitute method for measuring total volatile hydrocarbons; reports amount of fuel as carbon present in the sample; method available from the U.S. EPA Robert S. Kerr Laboratory | Data used to monitor the reduction in concentrations of total fuel hydrocarbons (in addition to BTEX) due to natural attenuation | At initial sampling and at site closure | Collect 40 mL of water in glass vials with Teflon-lined caps; add sulfuric acid to pH 2; cool to 4°C | Fixed-base |
| Water | Volatile Organics | GS/MS method SW8240 | Handbook method | Method of analysis for chlorinated solvents and aromatic hydrocarbons for evaluation of cometabolic degradation; measured for regulatory compliance when chlorinated solvents are known site contaminants | Each sampling round | Collect water samples in a 40 mL VOA vial; cool to 4°C; add hydrochloric acid to pH 2 | Fixed-base |
| Water | Dissolved organic carbon (DOC) (optional) | A5310 C | An oxidation procedure whereby carbon dioxide formed from DOC is measured by an infrared spectrometer. The minimum detectable amount of DOC is 0.05 mg/L | An indirect index of microbial activity | Each sampling round | Collect 100 mL of water in an amber glass container with Teflon-lined cap; preserve with sulfuric acid to pH less than 2; cool to 4°C | Fixed-base |
| Water | pH | E150.1/SW9040, direct reading meter | Protocols/Handbook methods | Aerobic and anaerobic processes are pH-sensitive | Each sampling round | Collect 100–250 mL of water in a glass or plastic container; analyze immediately | Field |

| Matrix | Analysis | Method/Reference | Comments | Data Use | Recommended Frequency of Analysis | Sample Volume, Sample Container, Sample Preservation | Field or Fixed-Base Laboratory |
|---|---|---|---|---|---|---|---|
| Water | Temperature | E170.1 | Field only | Well development | Each sampling round | N/A | Field |
| Water | Redox potential | A2580 B | Measurements are made with electrodes; results are displayed on a meter; samples should be protected from exposure to atmospheric oxygen | The redox potential of groundwater influences and is influenced by the nature of the biologically mediated degradation of contaminants; the redox potential of groundwater may range from more than 200 mV to less than -400 mV | Each sampling round | Collect 100–250 mL of water in a glass container, filling container from bottom; analyze immediately | Field |

**NOTES:**

1. "HACH" refers to the HACH Company catalog, 1990.
2. "A" refers to *Standard Methods for the Examination of Water and Wastewater*, 18th edition, 1992.
3. "E" refers to *Methods for Chemical Analysis of Water and Wastes*, U.S. Environmental Protection Agency, March 1979.
4. "Protocols" refers to the AFCEE *Environmental Chemistry Function Installation Restoration Program Analytical Protocols*, 11 June 1992.
5. "Handbook" refers to the AFCEE *Handbook to Support the Installation Restoration Program (IRP) Remedial Investigations and Feasibility Studies (RI/FS)*, September 1993.
6. "SW" refers to the *Test Methods for Evaluating Solid Waste, Physical, and Chemical Methods*, SW-846, U.S. Environmental Protection Agency, 3rd edition, 1986.
7. "ASTM" refers to the *American Society for Testing and Materials*, current edition.
8. "RSKSOP" refers to *Robert S. Kerr (Environmental Protection Agency Laboratory) Standard Operating Procedure.*
9. "LUFT" refers to the state of California *Leaking Underground Fuel Tank Field Manual*, 1988 edition.
10. *International Journal of Environmental Analytical Chemistry*, Volume 36, pp. 249-257, "Dissolved Oxygen and Methane in Water by a Gas Chromatography Headspace Equilibration Technique," by D. H. Kampbell, J. T. Wilson, and S. A. Vandegrift.

# APPENDIX B

# ADDITIONAL SITE DATA

# APPENDIX B - 1a

## BOREHOLE LOGS
## &
## WELL COMPLETION DETAILS

Borehole PS2-MW

# Log of Borehole

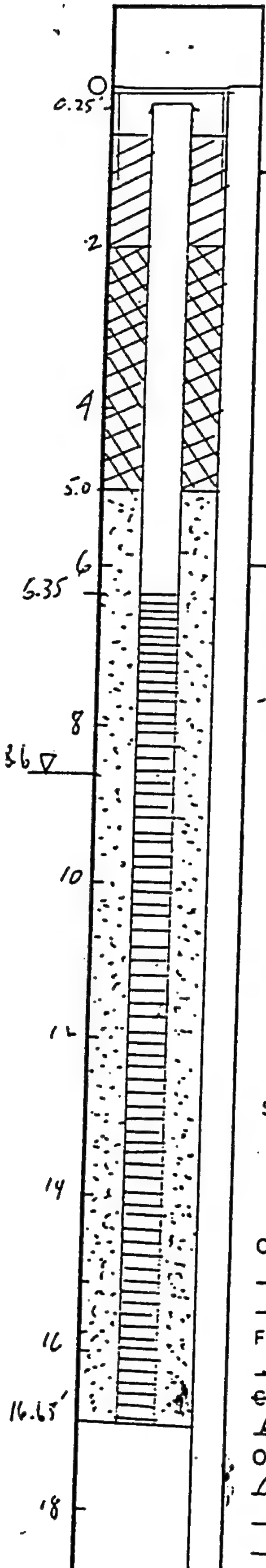
page 1 of 1

| | | |
|---|---|---|
| Project FAFB | Total Depth 16.65' | START / FINISH |
| Location PS2 - MW55 | Borehole Dia 8" | Date 10/30/88 / 10/30/88 |
| Geologic Log by James Moore | Depth to Fluid 8.6' BGS | Time 0802 / 0956 |
| Driller Lynn Bartholomew | Rig Canterra 150 | How Left Below ground well completion |
| Geophysics by none | Bit(s) finger bit | |
| Weather clear & mild | Fluid — | |

| Depth | Pene. Rate/ Blow Cts | Circulation Q (gpm) | OVA/ HNU Hole | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | 0-3' - Asphalt - fill material removing | |
| | | | | | | | 3.0-3.5' - Organic rich silt | |
| 3' | 18,17,B | | 5 | | 3-4.5 | | very fine grained, well sorted | |
| | | | | | | | 5Y2.5/1 black sl moist (OL) | |
| | | | | | | | 3.5-4.5 Silty sand, fine | |
| | | | | | | | gr. sand, well sorted sub | |
| | | | | | | | angular, qtz sand, med | |
| | | | | | | | dense not plastic sl. moist | |
| | | | | | | | 5Y4/1 dk gray (SM) | 95% |
| 8 | 7,7,7 | | 2.5 | | 8-9.5 | | 8-9.5' - Silty sand - predominantly | |
| | | | | | | | silt - well sorted w/ minor | |
| | | | | | | | fine gr. sand and mica, very | |
| | | | | | | | loose - increasing moisture | |
| | | | | | | | content - organic rich | |
| | | | | | | | 5Y 2.5/1 black (SM) | 100% |
| 13 | 6,10,30/5" | | 2.0 | | 13-14.5 | | 13-13.75 clay, very plastic | |
| | | | | | | | moist, soft, 5G 4/2 greyish green (CL) | |
| | | | | | | | 13.75-14.25 - Sand w/ minor | |
| | | | | | | | silt well sorted, med-coarse gr. | |
| | | | | | | | subangular, predominately qtz | |
| | | | | | | | basalt & mica - very dense | |
| | | | | | | | saturated 5GY 4/1 dk greyish | |
| | | | | | | | green (SP) | 80% |
| 16.6 | | | 2.0 | | 16 | | 16.6' Bit refusal basalt? | 0% |
| | | | | | | | Very hard | |

Source: SAIC, 1990

Hnu background 0.20 ppm




# Well Construction Summary

Location: PS2-MW55

Personnel: J. Moore

Elevation: Ground Level

Top of Casing

**DRILLING SUMMARY:**

Total Depth 16.6'

Borehole Diameter 8"

Driller Mike (Bartholomew Bros)

Rig Canterra 150

Bit(s) finger bit → hollow stem auger

Drilling Fluid none

Surface Casing below grd completion

**WELL DESIGN:**

Basis:

Geologic Log Geophysical Log

Casing String(s): C=Casing S=Screen

-0.25 - 6.35 C1

6.35 - 16.6 S1

Casing: C1 2" PVC SCH 40

~~C2~~

~~C3~~

~~C4~~

Screen: S1 2" stainless steel

~~S2~~ 0.020" Slot

~~S3~~

~~S4~~

Centralizers none

Filter Material 10-20 Colorado Silica Sand

~~Cemen:~~ 1/4" Enviroplug bentonite pellets

Other Type I/II Portland Cement

**CONSTRUCTION TIME LOG:**

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: 8" | 10/30/88 | 0802 | 10/30/88 | 0856 |
| Geophys. Logging: | | | | |
| Casing: 2" | 10/30 | 0900 | 10/30 | 0907 |
| Filter Placement | 10/30 | 0910 | 10/30 | 0942 |
| Cementing | 10/30 | 1000 | 10/30 | 1015 |
| Bentonite Seal | 10/30 | 0943 | 10/30 | 0948 |
| Other: | | | | |

Comments:

Below ground flush mount well completion

$H_2O$ 8.6' BGS

Key:

Bentonite

Cement/Grout

Sand Pack

Drill Cuttings

Gravel

Sand

Silt

Clay

Screen

Source: SAIC, 1990

Borehole PS2-Mu

# Log of Borehole

page 1 of 1

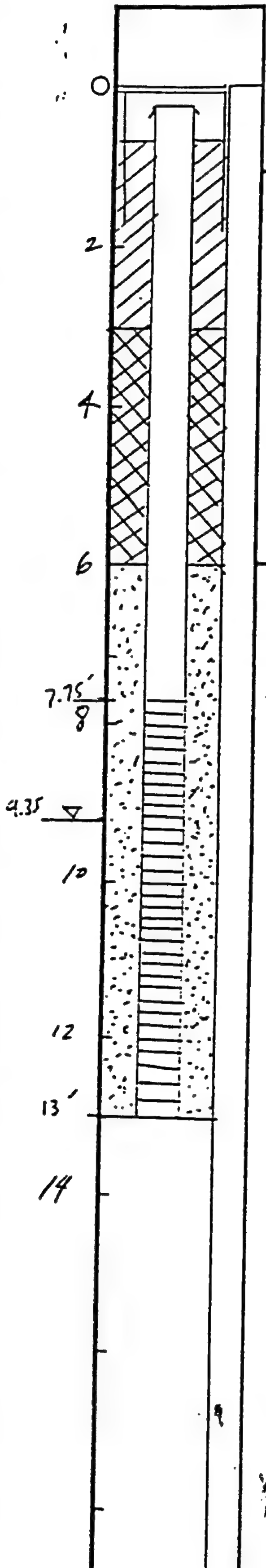
| | | |
|---|---|---|
| Project FAFB | Total Depth 13.0' | START / FINISH |
| Location PS-2 - MW56 | Borehole Dia 8" | Date 10/30/88 / 10/30 |
| Geologic Log by J. Moore | Depth to Fluid 9.35' | Time 1145 / 1243 |
| Driller Mike (B. Brox) | Rig Canterra 150 | How Left below grd |
| Geophysics by none | Bit(s) Finger Bit | well completion |
| Weather Clear | Fluid | |

| Depth | Pene. Rate/ Blow Cts | ~~Circulation Q (gpm)~~ | ppm OVA/ HNU hole | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | 0-.5' Asphalt | |
| | | | | | | | .5-3.0' Silty sand w/gravel (fill?) | |
| | 28,13,10 | | 1.2 | | | | 3.0-3.5 Organic rich silt | |
| | | | | | | | w/ minor fine gr. sand, w/ | |
| | | | | | | | mica 5Y 2.5/1 black (OL) | |
| | | | | | | | 3.5-4.5 - Silty sand - med - | |
| | | | | | | | coarse gr., sub angular, qtz, | |
| | | | | | | | med. dense - v. sl. moist | |
| | | | | | | | 5Y 4/2 olive gray (SM) | 100% |
| | 15,18,10 | | 7.0 | | | | 8.0-8.5 gravel sand clay | |
| | | | | | | | mixture, med - course gr sand, | |
| | | | | | | | w/ qtz, mica basalt, - poorly | |
| | | | | | | | sorted, sl. moist sl. | |
| | | | | | | | plastic 5GY 4/1 dk greenish | |
| | | | | | | | gray (GC) | |
| | | | | | | | 8.5-9.0 - Gravel sand mix | |
| | | | | | | | w/ large - 2" clasts of basalt | 70% |
| | | | | | | | (vesicular) - sand: v. coarse, | |
| | | | | | | | subangular, qtz, plag, minor | |
| | | | | | | | muscovite, & k-spar, saturated | |
| | | | | | | | w/ $H_2O$ | |
| | | | | | | | 13-14 Gravel sand mix → sluff? | |
| | | | | | | | Saturated w/ $H_2O$ - very | |
| | | | | | | | course grained, subangular | |
| | | | | | | | sand - qtz, plag, k-spar, basalt, | |
| | | | | | | | mica, well sorted (GW) | |

Hnu Background 0.6 ppm

Source: SAIC, 1990

# Well Construction Summary




Location: PS2- MW56
Personnel: J. Moore

Elevation: Ground Level ______
Top of Casing ______

**DRILLING SUMMARY:**

Total Depth 13.0'
Borehole Diameter 8"
Driller Mike (Bartholomew)
Rig CME Terra 150
Bit(s) finger bit - pilot hollow stem augers
Drilling Fluid none
Surface Casing below ground comp.

**CONSTRUCTION TIME LOG:**

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: 8" | 10/30/83 | 1145 | 10/30/83 | 1245 |
| Geophys. Logging: | | | | |
| Casing: 2" | 10/30 | 1308 | 10/30 | 1310 |
| Filter Placement | 10/30 | 1313 | 10/30 | 1337 |
| Cementing | 10/30 | 1400 | 10/30 | 1410 |
| Bentonite Seal | 10/30 | 1340 | 10/30 | 1345 |
| Other: | | | | |

**WELL DESIGN:**

Basis:
Geologic Log   Geophysical Log

Casing String(s): C=Casing S=Screen

| From | To | |
|---|---|---|
| -0.3 | 7.75 | C1 |
| 7.75 | 13.0 | S1 |

Casing: C1 2" PVC SCH 40
~~C2~~
~~C3~~
~~C4~~

Screen: S1 2" stainless steel
~~S2~~ 0.020" slot
~~S3~~
~~S4~~

Centralizers none

Filter Material 10-20 Colorado Silica Sand
Cement Type I/II Portland
Other Enviroplug pellets Bentonite

Comments:
Below ground well completion
$H_2O$ @ 9.35' BGS

Key:

| | |
|---|---|
| Bentonite | Sand |
| Cement/Grout | Silt |
| Sand Pack | Clay |
| Drill Cuttings | Screen |
| Gravel | |

Source: SAIC, 1990

Borehole MW-105

page 1 of 1

# Log of Borehole

| | | | |
|---|---|---|---|
| Project FAIRCHILD AFB | Total Depth 17.72 FT BGL | | START / FINISH |
| Location OU1 - MW105 | Borehole Dia 8-inch | Date | 8-23-90 / 8-24-90 |
| Geologic Log by Catherine Olsen | Depth to Fluid | Time | 1618 / 0802 |
| Driller Ponderosa Drilling / Robbie Mills | Rig Mobile Drill B-80 | How Left | Flush |
| Geophysics by NA | Bit(s) Continuous Core Sample | Mounted protective | |
| Weather 70°F, Sunny | Fluid None | Steel casing | |

| Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | |
|---|---|---|---|---|---|---|---|---|
| 0 | | | B=2 | | | | 0.0-1.0 FT: Sandy silt w/ organics. | |
| | | | H=1 | | | | fine roots. bslt clsts ≤ 30mm. | |
| | | | | | | | 10YR 6/2. Fill | |
| | | | | | | | 1.0-5.0 FT: Silty snd. fn to med. | |
| | | | | | | | poorly graded, mottled. 10YR 5/4 – | 52 |
| 5 | | | | | | | 10YR 3/2, occas. ≤ 3 mm pebble | |
| | | | | 1 | 7.0-8.5 | | 5.0-7.0 FT: v. crs snd. 10YR 5/4, | |
| | | | B=2 | | | | loose, occas > 50 mm bslt clst | |
| | | | H=1 | | | | 7.0-8.0 FT: Crs snd w/ gravel, | |
| | | | | | | | QTZ, K-spar Plag., well-graded. | 50 |
| 10 | | | | | | | 10YR 5/1 | |
| | | | | | | | | |
| | | | | | | | 9.0-17.0 FT: Sandy silt. v. | |
| | | | | | | | dry, weathered, fine to med | |
| | | | B=2 | | | | grain Occas. ≤ 10 mm bslt | |
| 15 | | | H=2 | | | | clst. drilling becoming rough | |
| | | | | | | | and more difficult | |
| | | | | | | | | |
| | | | | | | | T.D. = 17.72 FT | |
| 20 | | | | | | | | |

Source: SAIC, 1990

# Log of Borehole

Borehole MW-106

page 1 of 1

| | | |
|---|---|---|
| Project FAIRCHILD AFB | Total Depth 12.69 FT BGL | START / FINISH |
| Location OU1-MW106 (FS-2) | Borehole Dia 8-inch | Date 8-24-90 / 8-24-90 |
| Geologic Log by Catherine Olsen | Depth to Fluid 7.52 FT BGL | Time 1054 / 1325 |
| Driller Fortenson Drilling / Robbie [illegible] | Rig Mobile Drill B-90 | How Left Flush |
| Geophysics by NA | Bit(s) Continuous Core Sampler | Mounted Protective |
| Weather 72°F, sunny | Fluid None | Steel casing |

| Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | | | B=2 | | | | 0.0-1.0 FT: Organic silt w/ occas. | |
| | | | H=3 | | | | ≤10 mm bslt clast, rndd to sub- | |
| | | | | | | | rndd. 10YR 2/2, roots | |
| | | | | | | | | |
| 2 | | | | | | | 1.0-5.0 FT: Sandy silt, med to | |
| | | | | | | | course grn snd w/ QTZ, bslt, | |
| | | | | | | | mica, K-spar, loose, dry, | |
| | | | B=2 | | | | 10YR 2/2, Grayish soil @ approx | |
| 4 | | | H=8 | | | | 3.0 FT w/ fuel odor | |
| | | | | | | | | |
| | | | | | | | | |
| | 0.56 | | | 1 | 5.0-6.5 | | | 50 |
| | | | | | | | 5.0-8.0 FT: Sandy silt, med to | |
| 6 | | | B=2 | | | | Course grn, subang to ang, dry, | |
| | | | H=3 | | | | loose, mottled (10YR 7/1, 10YR 6/1, | |
| | | | | | | | 10YR 6/6) light gray to gray | |
| | | | | | | | areas have v. strong fuel odor | |
| | | | | | | | | |
| 8 | Water Level @ 8.0 FT | | | | | | | |
| | | | | | | | 8.0-10.0 FT: Basalt gravel, | |
| | | | | | | | ≤20 mm, subrndd to subang, | |
| | | | C=200 | | | | v. weathered, 20% clay, wet, | |
| 10 | 0.83 | | B=2 | 2 | 10-11.5 | | loose, 10YR 3/2, occas > 50 mm | |
| | | | H=300 | 3 | 10-11.5 | | basalt clast (weathered) | 50 |
| | | | | | | | | |
| | | | | | | | 10.0-12.0 FT: No core collected | |
| | | | | | | | Drilling rough and uneven. | |
| 12 | 0.13 | | B=2 | | | | weathered zone (?) | |
| | | | H=10 | | | | | 20 |
| | | | | | | | Bit Refusal at 12.7 FT | |
| | | | | | | | T.D. = 12.69 FT | |

B = Background
H = Borehole
C = Core

Source: SAIC, 1990

Borehole MW-101

# Log of Borehole

Page 1 of 1

| | | |
|---|---|---|
| Project FAIRCHILD AFB | Total Depth 15.99 FT BGL | START / FINISH |
| Location OU1-MW109 (PS2) | Borehole Dia 8-inch | Date 8-27-90 / 8-27-90 |
| Geologic Log by Katherine Olsen | Depth to Fluid | Time 1030 / 1315 |
| Driller Ponderosa Drilling / Farm Mills | Rig Mobile Drill F-80 | How Left Flush |
| Geophysics by NA | Bit(s) Chisel Bit / Continuous Core | mounted Protective |
| Weather 71 °F. Sunny | Fluid None | Steel |

| Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.07 | | B=Ø | | | | 0.0-0.33 FT: Asphalt (4.0") | |
| | | | H=Ø | | | | 0.5-3.0 FT: Fill Mat. (?), silty | |
| | | | | | | | snd coarse grain occas ≤15mm bslt | |
| | | | | | | | 3.0-5.0 FT: Silty sand, course grn | |
| | | | | | | | sr ang to sbrnd, well-sorted. Dry, | |
| | | | | | | | loose, 4.0-5.0 FT gray mod. | |
| | | | | | | | fuel odor, ≤ 40 mm bslt clast. | |
| | | | | | | | V. coarse sand, subang to ang. | |
| | | | | | | | wet | |
| 5 | 0.63 | | B=Ø | | | | | 50 |
| | | | H=47 | 1 | 5.0-6.5 | | 5.0-10.0 FT: sandy silt, fine | |
| | | | C=40 | 2 dup | 5.0-6.5 | | to coarse grn, rndd to sbang. | |
| | | | | | | | Basalt gravel, ≤ 40 mm 8.5- | |
| | | | | | | | 10.0 FT wet, loose 2.5Y 4/0 | |
| | Water @ 8.0 FT | | | | | | Strong fuel odor | |
| 10 | | | B=0.1 | | | | | 50 |
| | | | H=72 | | | | 10.0-15.0 FT: Basalt gravel, | |
| | | | C=150 | | | | silty ≤25mm v. wet loose, | |
| | 0.03 | | | | | | 2.5Y4/0 (gray), At 11.5 ft color | |
| | | | | | | | change to 10YR 5/6 yellowish | |
| | | | | | | | brown basalt weathered — | |
| | | | | | | | (Core sample collected from 10.0 | |
| | | | | | | | to 11.5 FT). | |
| | | | | | | | Bit refusal @ 15.9 FT | |
| 15 | | | | | | | TD = 15.99 FT | |

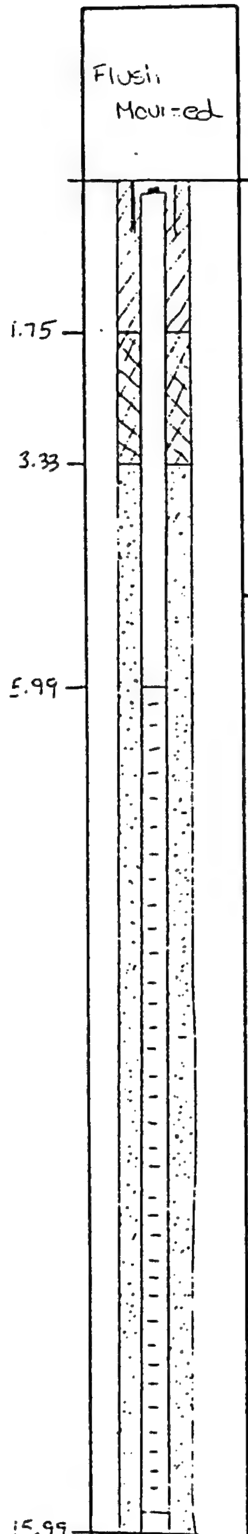
Source: SAIC, 1990

# Well Construction Summary

(PS-2)

Location: OU1 - MW109 Elevation: Ground Level ______

Personnel: Catherine Olsen Top of Casing ______




**DRILLING SUMMARY:**

Total Depth 15.99 FT BGL

Borehole Diameter 8-inch

Driller Fordamen Drilling - Patti Mills

Rig Mobile Drill B-80

Bit(s) Continuous Core Sampler

Drilling Fluid None

Surface Casing Protective Steel Flush Mounted

**WELL DESIGN:**

Basis:

Geologic Log X Geophysical Log

Casing String(s): C=Casing S=Screen

| | | | | | | |
|---|---|---|---|---|---|---|
| 0.0 | - | 5.99 | C | | - | |
| 5.99 | - | 15.99 | S | | - | |

Casing: C1 2-in dia. Sch 40 PVC

~~C2~~ Flush Threaded

~~C3~~

~~C4~~

Screen: S1 2-in dia Sch 40

~~S2~~ stainless steel

~~S3~~ Flush Threaded

~~S4~~ w/ 0.020" slots

Centralizers None

Filter Material 10-20 Colorado Silica Sand 3-100 lb sacks

Cement Portland Type I + II w/ powdered bentonite (3-94 lb sacks)

Other [illegible] fo [illegible] stainless [illegible] cap 6" PVC casing locking cap

**CONSTRUCTION TIME LOG:**

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: | 8-27-90 | 1030 | 8-27-90 | 1315 |
| Geophys. Logging: | | | | |
| Casing: | 8-27-90 | 1501 | 8-27-90 | 1502 |
| Filter Placement: | 8-27-90 | 1505 | 8-27-90 | 1527 |
| Cementing: | 8-27-90 | 1605 | 8-27-90 | 1625 |
| ~~Development:~~ Bentonite Plug | 8-27-90 | 1529 | 8-27-90 | 1535 |
| Other: Flush Mount | 8-25-90 | 1105 | 8-25-90 | 1120 |

Comments:

Key:

- Bentonite
- Sand
- Cement/Grout
- Silt
- Sand Pack
- Clay
- Drill Cuttings
- Screen
- Gravel

Source: SAIC, 1990

Borehole MW-110

page 1 of 1

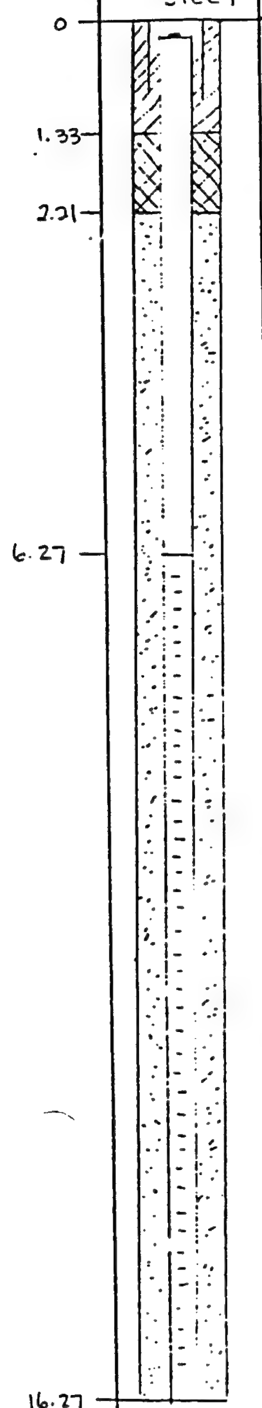
# Log of Borehole

| | |
|---|---|
| Project | FAIRCHILD AFB |
| Location | OU1-MW110 (PS-2) |
| Geologic Log by | Catherine Olson |
| Driller | Ponderosa Drilling / Robbi Mills |
| Geophysics by | NA |
| Weather | 80°F. Sunny |
| Total Depth | 16.27 FT BGL. |
| Borehole Dia | 8-inch |
| Depth to Fluid | |
| Rig | Mobile Drill B-?? |
| Bit(s) | Continuous Core Sampler |
| Fluid | None. |

| | START | FINISH |
|---|---|---|
| Date | 8-28-90 | 8-28-90 |
| Time | 0730 | 0910 |
| How Left | Flush mounted Protective Steel | |

| Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | |
|---|---|---|---|---|---|---|---|---|
| 0 | 0.14 | | | | | | 0-5 inches: Asphalt | |
| | | | | | | | 0.4 - 5.0 FT: Sandy Silt, (40-50% snd), crs grn, loose, dry, Basalt Gravel ≤ 30 mm, subrndd | |
| | | | B=0.1 | | | | 10YR 4/2, sl. fel odor | 50 |
| 5 | 0.63 | | H=7 | | | | | |
| | | | C=5 | 1 | 5.0-6.5 | | 5.0-10.0 FT: Sandy silt, fine to crs grain, subrnd to subang. mod. moist grading to saturated. 5Y 4/1 | |
| | | Water Level @ 9.0 FT | | | | | | |
| | | | B=0.1 | | | | | 50 |
| 10 | 0.71 | | H=0.2 | 2 | 10.0-11.5 | | 10.0-15.0 FT: Sandy silt w/ 60-70% v. crs snd. rndd to subang. saturated. loose. occas. Basalt clast ≤ 40 mm, subrndd to subang. 5Y 4/0 | |
| | | | C=Ø | | | | | 50 |
| 15 | | | B=0.1 | | | | 15.0-16.0 FT: Basalt gravel ≤ 45 mm, very weathered. fine to crs snd subrnd to subang minor clay (10%). 10YR 5/6, mod. moist. | |
| | | | H=0.1 | | | | | |
| | | | C=Ø | | | | | |
| 20 | | | | | | | T.D. = 16.27 FT BGL | |

Source: SAIC, 1990




# Well Construction Summary
(PS-2)

Location: NLI-MW110

Elevation: Ground Level ______

Personnel: Catherine Olsen

Top of Casing ______

**DRILLING SUMMARY:**

Total Depth 16.27 Ft BGL

Borehole Diameter 8-inch

Driller Ponderosa Drilling — Patri Mills

Rig Mobile Drill B-80

Bit(s) Continuous Core Sampler

Drilling Fluid None

Surface Casing Flush mounted protective [illegible]

**WELL DESIGN:**

Basis:
Geologic Log  Geophysical Log

Casing String(s): C=Casing S=Screen

| From | To | Type |
|---|---|---|
| 0.0 | 6.27 | C |
| 6.27 | 16.27 | S |

Casing: C1 2-inch Sch. 40 PVC
~~C2~~
~~C3~~
C4

Screen: S1 2-inch Sch 40
~~S2~~ Stainless Steel
~~S3~~ Flush Threaded
S4 w/ 0.020" slots

Centralizers None

Filter Material 10-20 Colorado Silica Sand (3-1/2 ... [illegible])

Cement [illegible]

Other [illegible]

**CONSTRUCTION TIME LOG:**

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: | 8-22-90 | 0730 | 8-22-90 | 0910 |
| Geophys. Logging: | | | | |
| Casing: | 8-28-90 | [illegible] | 8-28-90 | 0947 |
| Filter Placement: | 8-28-90 | 0949 | 8-28-90 | 1036 |
| Cementing: | [illegible] | 1046 | 8-28-90 | 1059 |
| ~~Development:~~ Bentonite Plug | 8-28-90 | [illegible] | 8-28-90 | 1041 |
| Other: Flush Mount | 8-29-90 | | 8-29-90 | |

Comments:
- Sand pack settled out in 2.21 ft BGL

Key:
Bentonite
Sand
Cement/Grout
Silt
Sand Pack
Clay
Drill Cuttings
Screen
Gravel

Source: SAIC, 1990

MW 176

Borehole Loc#3

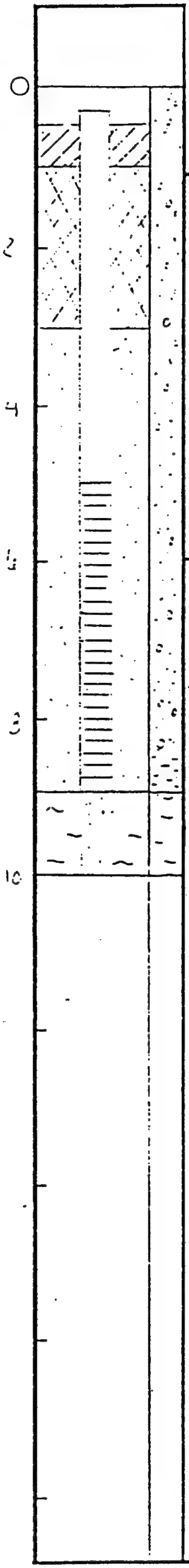
# Log of Borehole

page 1 of 1

| | | |
|---|---|---|
| Project FAFB | Total Depth 10' | START / FINISH |
| Location PS 2 | Borehole Dia 8" | Date 11-16-91 / 11-16-91 |
| Geologic Log by G. Di Gregorio | Depth to Fluid 7' | Time 0826 / 0919 |
| Driller Dan Claassen | Rig Mobile Drill B61 | How Left grouted |
| Geophysics by NA | Bit(s) 8" Auger | flush mount well |
| Weather Foggy 25°F, breezy | Fluid NA | monument |

| Depth | Pene. Rate/ Blow Cts | Circulation Q (gpm) | OVA/HNU sample/wall ppm | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | | |
| | | | | | | | Coarse sand and gravel, poorly sorted, ang, ≤ 20 mm (mod basalt) greenish gray color | |
| 2 | | | 45/45 | | 0-1 | | | 25% |
| | | | | | | | Coarse sand w/ minor gravels ≤ 40 mm, ang, mod sorted basalt, qtz & felds w/ greenish gray coloring | |
| 4 | | | 45/45 | | 2-4 | | | 75% |
| | | | | | | | Coarse sand & gravel ≤ 41 mm ang, mod sorted, basalt, qtz & felds w/ greenish gray coloring | |
| 6 | | | 95/35 | | 4-6 | | | 75% |
| | | | | | | ▽ | Coarse sand and gravel ≤ 20 mm poorly sorted basalt qtz & felds. free product @ 7' BGS black oil appearance | |
| 8 | | | 120/111 | | 6-8 | | | 75% |
| | | | | | | | silty sands and gravels ≤ 20 mm, ang, poorly sorted, to 8.4' grades to silty clay dark gray ≈ 8.9 grades to clay w/ silt | |
| 10 | | | 50/100 | | 8-10 | | stiff plastic dense gray (free product | 100% |
| | | | | | | | TD @ 8.9' | |

Source: HNUS, 1993




# Well Construction Summary

MW 176

Location: PSZ ~~[illegible]~~ Elevation: Ground Level ______

Personnel: G. DiGregorio Top of Casing ______

## DRILLING SUMMARY:

Total Depth 10'

Borehole Diameter 8"

Driller Dan Clark [illegible] Environmental [illegible]

Rig Mobile Drill B61

Bit(s) 8" Auger

Drilling Fluid NA

Surface Casing NA

## WELL DESIGN:

Basis:
Geologic Log Geophysical Log

Casing String(s): C=Casing S=Screen

| | | |
|---|---|---|
| 0.2 - 5 | C | |
| 5 - 10 | S | |

Casing: C1 Schedule 40 2" PVC
C2
C3
C4

Screen: S1 Schedule 40 2" [illegible]
S2 0.010 slot
S3
S4

Centralizers N/A

Filter Material CST 10/20 Sand

Cement Portland Type I - Type II [illegible] bentonite gel

Other [illegible] bentonite pellets [illegible]

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: | 11-11-91 | 0820 | 11-11-91 | [illegible] |
| Geophys. Logging: | | | | |
| Casing: | 11-11-91 | 0920 | 11-11-91 | 0925 |
| Filter Placement | 11-11-91 | 0930 | 11-11-91 | 0942 |
| Cementing: | 11-11-91 | 1015 | 11-11-91 | 1015 |
| Bentonite Seal: | 11-11-91 | 0944 | 11-11-91 | 0945 |
| Other: | | | | |

Comments: [illegible] bentonite w/ 5 gals of [illegible] water. [illegible] [illegible] [illegible] well movement

Key:
Bentonite
Sand
Cement/Grout
Silt
Sand Pack
Clay
Drill Cuttings
Screen
Gravel

Source: HNUS, 1993

MW 177

Borehole Loc #1 [illegible]

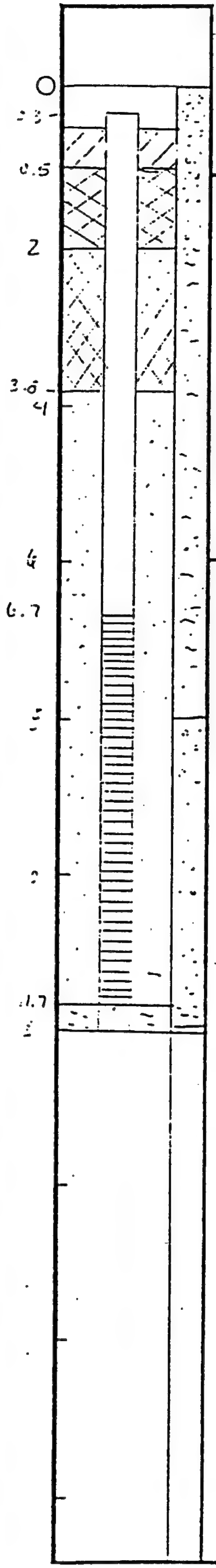
# Log of Borehole

page 1 of 1

| | | | |
|---|---|---|---|
| Project FAFB | Total Depth 12' | | START / FINISH |
| Location PSZ- | Borehole Dia 8" | Date | 11-15-91 / 11-15-91 |
| Geologic Log by G. DiGregorio | Depth to Fluid 8' | Time | 1040 / 1203 |
| Driller Dan Claussen / Envir. West | Rig Mobile Drill B 61 | How Left | w/ flush |
| Geophysics by NA | Bit(s) 8" Auger | | mount well monument |
| Weather overcast, 40°F foggy | Fluid NA | | in place |

| Depth | Pene./Rate/Blow Cts | Circulation Q (gpm) | OVA/HNU sample/hole | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description | % Core Recovery |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | | gravels and sand poorly sorted ± 40 mm, ang. basalt & felds spoon refusal @ 1' | |
| | | | | | | | auger cuttings color change from brown to gray @ 2" | |
| 2 | | | 0/0 | | 0-1 | | | 40% |
| | | | | | | | clay w/ lenses of sand coarse grain, well sorted, ang. basalt qtz & felds. strong fuel odor | |
| | | | | | | | clay dark gray dense med plasticity - some grayish green lenses | |
| 4 | | | 50/60 | | 2-4 | | | 100% |
| | | | | | | | sandy clay med-coarse grain ang., poorly sorted, 20%-50% sand, clay, dense stiff dry non-plastic dark gray | |
| 6 | | | 5/10 | | 4-6 | | | 100% |
| | | | | | | ▽ | clay w/ sands dark gray moist w/ fuel appearance (slick) grading to sand coarse grain @ 8' greenish gray | |
| 8 | | | 180/80 | | 6-8 | | | 25% |
| | | | | | | | coarse sand well sorted ang., basalt qtz & felds grayish green fluid wet @ 9' free product | |
| 10 | | | 85/110 | | 8-10 | | | 50% |
| | | | | | | | coarse sand w/ minor gravel well sorted, ang. basalt qtz & felds minor clay lenses stiff plastic greenish gray. 12' | |
| 12 | | | 15/150 | | 10-12 | | TD @ 11.7' BGS | 15% |

Source: HNUS, 1993




# Well Construction Summary

Location: MW 177 PSC2 - ~~L=1 [illegible]~~ Elevation: Ground Level ____________

Personnel: G. D. Greger Top of Casing ____________

## DRILLING SUMMARY:

Total Depth 12'

Borehole Diameter 8"

Driller Don Claassen
Environmental [illegible]

Rig Mobile Drill [illegible]

Bit(s) 6" Augers

Drilling Fluid N/A

Surface Casing N/A

## WELL DESIGN:

Basis:
Geologic Log Geophysical Log

Casing String(s): C=Casing S=Screen

| | | | | | |
|---|---|---|---|---|---|
| 0.3 - 6.7 | C | - | | - | |
| 6.7 - 11.7 | S | - | | - | |

Casing: C1 2" Schedule 40 PVC
C2
C3
C4

Screen: S1 2" schedule 40 PVC
S2 [illegible]
S3
S4

Centralizers N/A

Filter Material CS [illegible] Sand
16/20

Cement Portland Type I - Type II

Other Bentonite gel
Bentonite hole plug
Bentonite pellets [illegible]

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: | | | | |
| | 11-15-91 | [illegible] | 11-15-91 | [illegible] |
| Geophys. Logging: | | | | |
| Casing: | 11-15-91 | [illegible] | 11-15-91 | [illegible] |
| Filter Placement | 11-15-91 | [illegible] | 11-15-91 | [illegible] |
| Cementing: | 11-15-91 | 1303 | 11-15-91 | 1320 |
| Bentonite Seal: | 11-15-91 | 1234 | 11-15-91 | [illegible] |
| Other: | | | | |
| hole plug | 11-15-91 | [illegible] | 11-15-91 | [illegible] |

Comments:
Flush mount well monument
installed [illegible]
[illegible]

Key:

Bentonite
Sand
Cement/Grout
Silt
Sand Pack
Clay
Drill Cuttings
Screen
Gravel

Source: HNUS, 1993

MW 178 Borehole PS-2 ~~Loc 3~~

Page 1 of 1

# Log of Borehole

| | |
|---|---|
| Project | FAIRCHILD AFB |
| Location | PS-2 Loc 3BS |
| Geologic Log by | Chuck Howe - SAIC |
| Driller | Louie Hammer - Ponderosa |
| Geophysics by | |
| Weather | foggy - 30° - slight drizzle |
| Total Depth | 32' |
| Borehole Dia | 8" |
| Depth to Fluid | 9-10' |
| Rig | CP 7000 |
| Bit(s) | 8" tricone - 8" rock hammer bit |
| Fluid | air/water |

| | START | FINISH |
|---|---|---|
| Date | 11/6/91 | 11/6/91 |
| Time | 0850 | 0952 |
| How Left | water tight | |
| | flush surface monument | |
| | expanding plug w/o lock | |

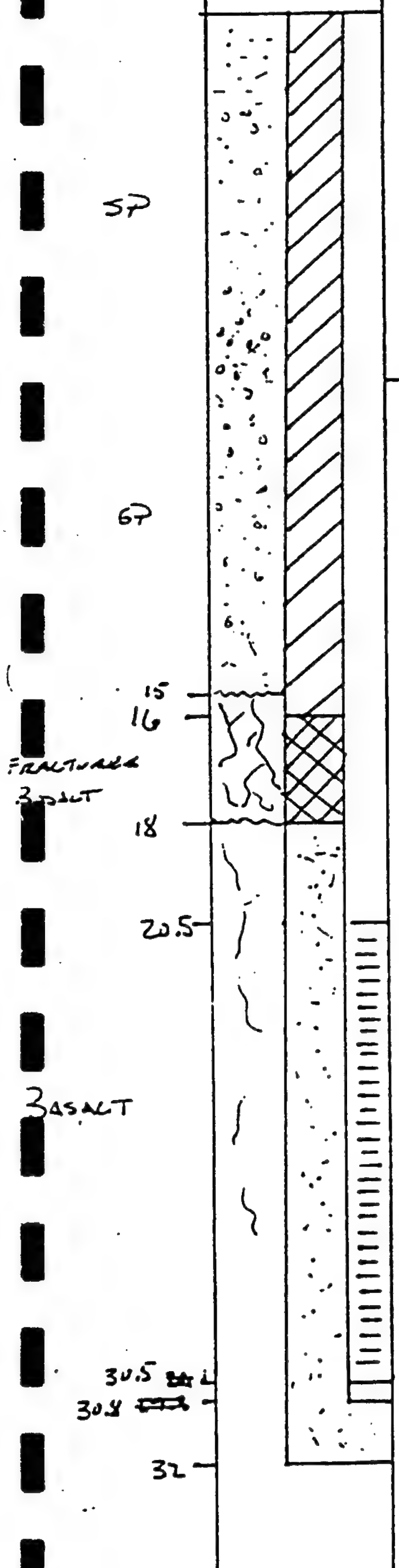
| Time | Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | 4" asphalt base |
| 0853 | 5 | | | | | | | sand, med-coarse, some pebbles <20mm angular to subangular, basalt, quartz, K spar, mod sorted; strong petro odor ~8' |
| 0858 | 10 | | | | | | ▽ | sandy gravel - granules, angular, basalt |
| 0905 | 15 | | | | | | | gravel - granules to pebble < 30mm - mod sorted, angular to subangular - basalt - chip coating - fractured - heavily weathered basalt; weathered basalt reddish brown surface; Beginning to firm up |
| 0919 | 20 | | | | | | | Basalt - slightly fractured, trace weathering, black 2.5/2 5Y |
| 0936 | 25 | | | | | | | Basalt massive - slightly fractured, trace weathering, 2.5/1 5Y |
| 0947 | 30 | | | | | | | Massive basalt - black 2/0 2.5Y |
| 0952 | | | | | | | | Basalt as above; TD 32' BGS |

Source: HNUS, 1993

# Well Construction Summary

Location: PS-2 MW 178 Loc 3 [illegible]
Personnel: Chuck Houck - SAIC

Elevation: Ground Level ______
Top of Casing ______




## DRILLING SUMMARY:

Total Depth 32'
Borehole Diameter 8"
Driller Louie Hanner - PONDEROSA
Rig CP 7000
Bit(s) 8" Tricone / 8" Rock hammer
Drilling Fluid Air/WATER
Surface Casing 8" steel 0 + 3 - 14

## WELL DESIGN:

Basis:
Geologic Log    Geophysical Log

Casing String(s): C=Casing S=Screen

| From | To | Type |
|---|---|---|
| 30.8 | 30.5 | C |
| 30.5 | 20.5 | S |
| | 0 | C |

Casing: C1 4"x4" PVC end cap
C2 4" Sch 40 PVC
C3
C4

Screen: S1 4" Sch 40 PVC 020 slot
S2
S3
S4

Centralizers NONE

Filter Material 10-20 silica sand

Cement PORTLAND I-II + 5% bentonite

Other annular seal - 3/8" bentonite pellets

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: Air Rotary | 11/6/91 | 0850 | 11/6/91 | 0957 |
| Geophys. Logging: | | | | |
| Casing: | 11/6/91 | 1020 | 11/6/91 | 1030 |
| Filter Placement: | 11/6/91 | 1030 | 11/6/91 | 1045 |
| Cementing: | 11/6/91 | 1150 | 11/6/91 | 1155 |
| Development: | | | | |
| Other: Pull casing | 11/6/91 | 1045 | 11/6/91 | 1150 |
| set surface monument | 11/6/91 | 1150 | 11/6/91 | 1250 |

Comments:

Key:
Bentonite
Cement/Grout
Sand Pack
Drill Cuttings
Gravel
Sand
Silt
Clay
Screen

Source: HNUS, 1993

MW 179 Borehole PS-2 ~~Loc 2~~

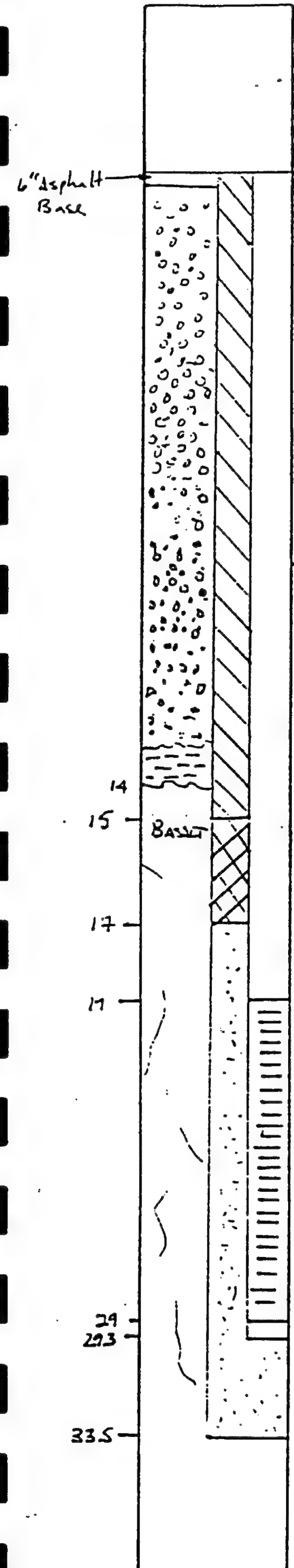
# Log of Borehole

page 1 of 1

| | | |
|---|---|---|
| Project FAIRCHILD AFB | Total Depth 33.5 | START FINISH |
| Location PS-2 · ZOC ZABR | Borehole Dia 8" | Date 11/5/91 11/5' |
| Geologic Log by CHUCK Hauck - SAIC | Depth to Fluid 11' | Time 0822 1003 |
| Driller Louie Hanner PONDEROSA | Rig CP 7000 | How Left flush surface |
| Geophysics by | Bit(s) 8" TRICONE / 8" rock hammer bit | monument w/ |
| Weather 30° drizzle | Fluid AIR/WATER | expanding plug w/o lock |

| Time | Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | |
| 0825 | 5 | | | | | 5 | GP | Gravel, tr coarse sand, pebbles < 30 mm, angular to sub angular mod sorted, basalt quartz, K-spar |
| 0828 | 10 | | | Strong petro odor | | 10 | | gravel, granule to pebbles < 20 mm, basalt tr quartz, sub angular to subrounded |
| | | | | | | | SM | Silty sand, fine-coarse, poorly sorted |
| | | | | | | | BR | Basalt - slightly fractured - trace weathering e 14 |
| 0830 | 15 | | | | | | | |
| 0848 | 20 | | | | | | | Massive basalt - slightly fractured trace weathering - |
| 0915 | 25 | | | | | | | Massive basalt - black - trace weathering |
| 0932 | 30 | | | | | | | Basalt as above |
| 0958 | | | | | | | | Basalt as above - TD BORING 33.5 |

Source: HNUS, 1993




# Well Construction Summary

Location: PS-2 ~~ZABR~~ MW179 (19)

Elevation: Ground Level ______

Personnel: Chuck Houck - SAIC

Top of Casing ______

## DRILLING SUMMARY:

Total Depth 33.5

Borehole Diameter 8"

Driller Louie Hanna - Ponderosa

Rig CP 7000

Bit(s) Tricone / Rock Hammer

Drilling Fluid Air/Water

Surface Casing 8" steel $^{+}$3-14

## WELL DESIGN:

Basis:

Geologic Log · Geophysical Log

Casing String(s): C=Casing S=Screen

| | | |
|---|---|---|
| 29.3 - 29 | C | |
| 29 - 19 | S | |
| 19 - 0 | C | |

Casing: C1 4" x 4" PVC end cap

C2 4" sch 40 blank casing

C3

C4

Screen: S1 4" PVC sch 40 slot 020

S2

S3

S4

Centralizers None

Filter Material 10-20 silica sand

Cement Portland Type II + 5% bentonite

Other annular seal - 3/8" bentonite pellets

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: Air Rotary | 11/5/91 | 0822 | 11/5/91 | 1000 |
| Geophys. Logging: | | | | |
| Casing: | 11/5/91 | 1030 | 11/5/91 | 1045 |
| Filter Placement: | 11/5/91 | 1045 | 11/5/91 | 1100 |
| Cementing: | 11/5/91 | 1115 | 11/5/91 | 1145 |
| Development: | | | | |
| Other: monument installment includes site cleanup | 11/5/91 | 1230 | 11/5/91 | 1350 |

Comments:

Key:

Bentonite
Cement/Grout
Sand Pack
Drill Cuttings
Gravel
Sand
Silt
Clay
Screen

Source: HNUS, 1993

MW1180 Borehole PS-2

# Log of Borehole

Page 1 of 2

| | | |
|---|---|---|
| Project FAIRCHILD AFB | Total Depth 62 | START / FINISH |
| Location PS-2- ~~Loc 1~~ | Borehole Dia 8 | Date 11/3/91 11/3/91 |
| Geologic Log by Chuck Houck SAIC | Depth to Fluid | Time 1230 1930 |
| Driller Louie Hunner - PONDEROSA | Rig CP 7000 | How Left flush |
| Geophysics by | Bit(s) 8" TRICONE | surface monument |
| Weather overcast 20° | Fluid AIR/WATER | w/expanding end plug |

| | Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description |
|---|---|---|---|---|---|---|---|---|
| | 0 | | | | | | | |
| | 5 | | | 0 | | 5 | | silty sand, some granules, fine to coarse poorly sorted, dk gray brown |
| 1240 | 10 | | | 0 | | 10 | | sandy silt, dk gray - black, v fine sands |
| 1242 | 15 | | | 0 | | 15 | GP | ~~sandy~~ gravel, pebbles (≤10mm) + granules - some coarse sand, subangular to rounded, basalt, blk |
| 1246 | 20 | | | 0 | | 20 | CL | sandy clay, gray brown, fine sand soft |
| 1301 | 25 | | | 0 | | 25 | Bedrock highly fractured | gravely sand, tr clay, f-coarse, poorly sorted, red, 4/8 2.5YR - very weathered basalt, angular Bedrock? |
| | 30 | | | 0 | | 30 | | No sample |

Source: HNUS, 1993

MW 1180 Borehole PS-2 ~~[illegible]~~

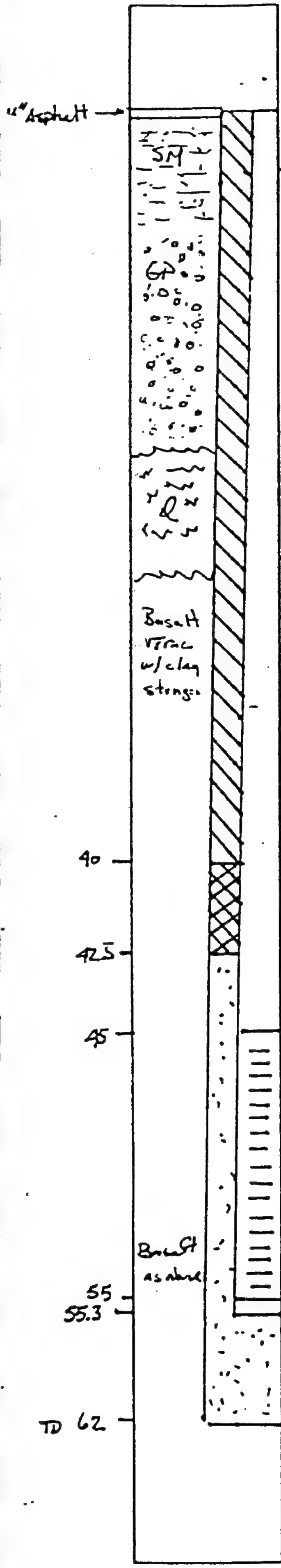
# Log of Borehole

page 2 of 2

| | | |
|---|---|---|
| Project FAIRCHILD AFB | Total Depth 62 | START FINISH |
| Location PS-2 ~~[illegible]~~ MW180 | Borehole Dia 8" | Date 4/3/91 11/3' |
| Geologic Log by Chuck Hauck - SAIC | Depth to Fluid | Time 1230 1930 |
| Driller Louie Hanner - Ponderosa | Rig CP-8000 | How Left surface |
| Geophysics by | Bit(s) 8" TRICONE | monument w/ expand- |
| Weather overcast - 20°F | Fluid AIR/WATER | end plug w/ lock |

| Depth ft | Pene. Rate ft/min | Circulation Q (gpm) | HNu PPM | Sample # | Sample Interval | Lith. Symbol | Geologic and Hydrologic Description |
|---|---|---|---|---|---|---|---|
| 0 | | | | | | | |
| 35 | | | 0 | | 35 | | Basalt - weathered - fractured w/ sandy clay, yellowish brown, fine sands |
| 1305 40 | | | 0 | | 40 | | Basalt - fractured, highly weathered |
| 1315 45 | | | 0 | | 45 | | Basalt - very angular, fractured, highly weathered, interbedded yellow clays. |
| 1318 50 | | | 0 | | 50 | | no change |
| 1320 55 | | | 0 | | 55 | | Basalt as above |
| 1325 60 | | | 0 | | 60 | | Basalt as above TD 62 |

Source: HNUS, 1993




# Well Construction Summary

MW 180

Location: PS-2 ~~lot~~ ~~BR~~

Elevation: Ground Level ______

Personnel: Chuck Houck - SAIC

Top of Casing ______

## DRILLING SUMMARY:

Total Depth 62

Borehole Diameter 8"

Driller Louis Hanna - PONDEROSA

Rig CP 7000

Bit(s) 8" TRICONE

Drilling Fluid AIR/WATER

Surface Casing 8" 0-17

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: Air Rotary | 11/3/91 | 1230 | 11/3/91 | 1330 |
| Geophys. Logging: | | | | |
| Casing: | ~~1330~~ 11/3/91 | 1430 | 11/3/91 | 1500 |
| Filter Placement: | 11/3/91 | 1500 | 11/3/91 | 1525 |
| Cementing: | 11/3/91 | 1515 | 11/3/91 | 1600 |
| Development: | | | | |
| Other: set monument | 11/8/91 | 1630 | 11/3/91 | 1800 |

## WELL DESIGN:

Basis:
Geologic Log    Geophysical Log

Casing String(s): C=Casing S=Screen

| | | |
|---|---|---|
| 55.3 - 55 | C |
| 55 - 45 | S |
| 45 - 0 | C |

Casing: C1 4"x4" threaded PVC end cap
C2 4" sch 40 PVC
C3
C4

Screen: S1 4" sch 40 PVC 020 slot
S2
S3
S4

Centralizers None

Filter Material 10-20 silica sand

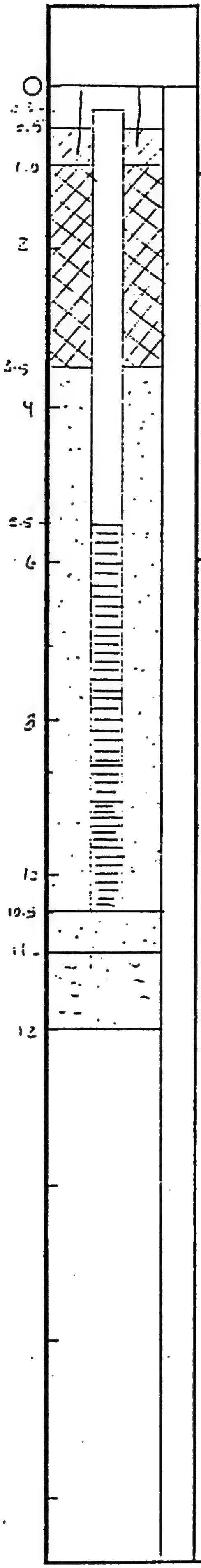
Cement PORTLAND 1-11 + 5% bentonite

Other annular seal - 3/8" bentonite pellets

Comments:

Key:
Bentonite
Sand
Cement/Grout
Silt
Sand Pack
Clay
Drill Cuttings
Screen
Gravel

Source: HNUS, 1993




# Well Construction Summary

Location: PSS [illegible] MW15 [illegible] Elevation: Ground Level ______

Personnel: G. D. Gregoric Top of Casing ______

## DRILLING SUMMARY:

Total Depth 12'

Borehole Diameter 8"

Driller [illegible] Environmental [illegible]

Rig Mobile Drill B-61

Bit(s) 8" Augers

Drilling Fluid NA

Surface Casing NA

## CONSTRUCTION TIME LOG:

| Task | Start Date | Start Time | Finish Date | Finish Time |
|---|---|---|---|---|
| Drilling: | 11-14-91 | 08[illegible] | 11-14-91 | [illegible] |
| Geophys. Logging: | | | | |
| Casing: | 11-14-91 | 0915 | 11-14-91 | 0915 |
| Filter Placement | 11-14-91 | 0917 | 11-14-91 | 0931 |
| Cementing | 11-14-91 | 1033 | 11-14-91 | 10[illegible] |
| Bentonite Seal | 11-14-91 | 0932 | 11-14-91 | [illegible] |
| Other: | | | | |

## WELL DESIGN:

Basis:
Geologic Log Geophysical Log

Casing String(s): C=Casing S=Screen

| | | |
|---|---|---|
| 0.5 - 5.5 | C1 | |
| 5.5 - 10.5 | S1 | |

Casing: C1 Schedule 40 2" PVC
C2
C3
C4

Screen: S1 Schedule 40 2" PVC [illegible]
S2 [illegible]
S3
S4

Centralizers NA

Filter Material CSI Sand 10/20

Cement Portland

Other [illegible] 4" [illegible] bentonite [illegible] plug

## Comments:

hydrated bentonite w/ 5 gals of potable water
Installed flush mount well monument.

## Key:

Bentonite
Sand
Cement/Grout
Silt
Sand Pack
Clay
Drill Cuttings
Screen
Gravel

Source: HNUS, 1993

BORING LOG — NUS CORPORATION

PROJECT: FAEB — BORING NO. SB001, PS-2

PROJECT NO.: 3286 — DATE: 10/31/91 — DRILLER: THERON L / BARTH

ELEVATION: — FIELD GEOLOGIST: FRED W RANSER

WATER LEVEL DATA:

(Date, Time & Conditions) 10/31/91 9:49 OVER CAST COLD 35°F BREEZY

| SAMPLE NO. & TYPE OR ROD | ① DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY SAMPLE LENGTH | LITHOLOGY CHANGE (Depth/Ft) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS (HNU) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈6" | | |
| S-1 1010 | | 4924 / 24 | | | MED DENSE | | | GM | S-1 (0.8) |
| | 2 | 49 / 49 | 1.5 / 2.0 | | | GRAY GRN | SILT, WELL GRADED SAND w/some GRAVELS GRAVELS ≤1/4" DIA. SUBROUNDED | | TR CLAY MOIST |
| S-2 1017 | | 17 / 20 | | | MED DENSE | D-GRN | CLAY SILT WELL GRADED SAND w/some GRAVEL ≤1.5" DIA | SW | S-2 (0.0) MOIST |
| | 4 | 13 / 21 | 1.5 / 2.0 | | | | | | |
| S-3 1025 | | 17 / 17 | | | SOFT | D-GRN | SILT CLAY some GRAVEL and FINE GRAVEL | ML | S-3 (0.4) |
| | 6 | 50/.5" | .9 / 1.0 | | | | | | SPOON REFUSAL SATURATED 5.9 |
| | 8 | | | | | | TD = 4' SAMPLED TO 6' | | |
| | | | | | | | $H_2O$ @ 5.9 | | |
| | 10 | | | | | | | | |

REMARKS CANTERA Rig 4¼" ID HSA, 2½" S.S. w/BRASS INSERTS 140lb Hammer dropped 30"

① ZERO DEPTH @ 6" BELOW ASPHALT TOP SURFACE

BORING SB001

PAGE 1 of 1

* SAMPLES CAPPED ARE INDICATED BY A CHECK MARK

CIRCLED SAMPLE INDICATES SAMPLE SENT TO LAB FOR ANALYSIS

Source: HNUS, 1993

BORING LOG WOODY — NUS CORPORATION

PROJECT: FAFB
PROJECT NO.: 3286
ELEVATION:
WATER LEVEL DATA:
(Date, Time & Conditions) 11/1/91 CLEAR COLD 32° WINDY 1430

DATE: 11/1/91
FIELD GEOLOGIST: FROUDRAUSCR

BORING NO. SB002 PS2
DRILLER: THEROU L. / BARTLI BROS

| SAMPLE NO & TYPE OR RQD | DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | U.S.C.S. | REMARKS SPLIT SPOON HNU → ppm |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈6" BASE ≈1.5' | | |
| | 2 | | | | | | | | |
| S-1 1437 | | 37 28 | | | DENSE | D-GRN | CLAYEY SILT SOME GRADED SAND TR GRAVEL ≤.5" | SC | S-1 SLIGHTLY MOIST FUEL ODOR (50. |
| | 4 | 47 48 | 1.4/2.0 | | | | ↓ | | |
| S-2 1448 | | 7 7 | | | Loose to MED DENSE | D-GRN | AS ABOVE | SC | S-2 SLIGHTLY MOIST FUEL ODOR (90.0 |
| | 6 | 10 14 | 1.3/2.0 | | | | | | |
| S-3 1500 | | 18 18 | | | MED DENSE TO LOOSE | D-GRN | GRADED SAND w/some SILT + GRAVEL TR/CLAY | SW-SM | S-3 MOIST FUEL ODOR (140.0 |
| | 8 | 15 9 | .5/2.0 | | | | | | |
| S-4 1507 | | 2 4 | | | Loose to MED DENSE | BLK D-GRN | SILTY CLAY TR GRADED SAND | CL | S-4 WET FUEL ODOR (140.0 |
| | 10 | 13 18 | 1.5/2.0 | | | | | | |
| S-5 1521 | | 5 8 | | | LOOSE | BLK D-GRN | SILTY CLAY some FINE SAND | CL | S-5 SATURATED (100.0) |
| | 12 | 8 12 | 1.5/2.0 | | | | | | |
| | | | | | | | TD = 10' SAMPLE TO 12 | | |
| | | | | | | | 5 SPOONS $H_2O$ @ 10.5 | | |

REMARKS CANTERA RIG 4¼ HSA 2½ S.S. w/BRASS INSERTS, 140 lb HAMMER DROPPED 30"

BORING SB002 PS

PAGE 1

✓ CAPPED INSERTS ARE INDICATED BY A CHECK MARK
CIRCLED SAMPLE # INDICATES SAMPLE SENT TO LAB FOR ANALYSIS

Source: HNUS, 1993

BORING LOG — NUS CORPORATION

PROJECT: FAFB — BORING NO: SB 003 - PS2
PROJECT NO.: 3286 — DATE: 11/3/91 — DRILLER: THERON L. / BAZT HOLOM
ELEVATION: — FIELD GEOLOGIST: P. NIMMER
WATER LEVEL DATA:
(Date, Time & Conditions) 11/3, 08:33 30° F., Cloudy.

| SAMPLE NO. & TYPE OR ROD | DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS (SPLIT SPOON HNU — ppm) |
|---|---|---|---|---|---|---|---|---|---|
| S-1 845 | | — / 44 | | | DENSE | GREY | Sandy SILT Some CLAY | | S-1 DRY (<1 PP. |
| | 2 | 44 / 44 | 1.2 / 2.0 | | | | | | |
| S-2 900 | | 50 / 55 | | | DENSE | GREY | Sandy SILT Some organic material | | S-2 DRY (0 PPM |
| | 4 | 37 / 37 | 1.5 / 2.0 | | | | | | |
| S-3 910 | | 13 / 12 | | | MED. DENSE | GREY | SANDY SILT | | S-3 DUP (0 PPM |
| | 6 | 20 / 25 | 2.0 / 2.0 | | | | | | |
| S-4 0915 | | 12 / 12 | | | MED DENSE | GREY | CLAYEY SILT | | MOIST (0 PPM |
| | 8 | 12 / 11 | 1.5 / 2.0 | | | | | | |
| S-5 0920 | | 3 / 3 | | | VERY loose to loose | GREY | CLAYEY SILT | | Fuel odor Sat. @ 9' (15 PPM |
| | 10 | 5 / 5 | 1.5 / 2.0 | | | | | | |
| | | | | | | | TD = 8' SAMPLED TO 10' | | |
| | | | | | | | $H_2O$ @ 9.0' 09:30 | | |

REMARKS: CANTERA RIG 4 1/4 H.S.A., 2 1/4 ID SPLIT SPOONS with Brass inserts.
140 lb HAMMER DROP 30 inches.
Asphalt 6" Thick.

BORING SB 003 - PS
PAGE ___ : ___

* Capped inserts indicated by ✓.

Source: HNUS, 1993

## BORING LOG — NUS CORPORATION

PROJECT: FAFB
PROJECT NO.: 3286
DATE: 11/5/91
ELEVATION:
BORING NO: SB004 - PS2
DRILLER: THEROU L. / BARTI GROS
FIELD GEOLOGIST: P. NIMMER/FREDW. ESLINGER
WATER LEVEL DATA:
(Date, Time & Conditions) 11/5/91 0945 30°F, CLOUDY

| SAMPLE NO. & TYPE OR RQD | DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth/Ft) OR SCREENED INTERVAL | SOIL DENSITY/CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS SPLITSPOON HNU (PPM) |
|---|---|---|---|---|---|---|---|---|---|
| S-1 0954 | | — / 40 | | | DENSE | | ASPHALT 6" WELL GRADED SAND SOME SILT TR CLAY + GRA | SW | GRA ≤ .5" (0.0) |
| | 2 | 40 / 40 | 1.0 / 1.5 | | | | | | |
| S-2 1000 | | 36 / 27 | | | MED DENSE TO DENSE | BRN | WELL GRADED SAND SOME SILT + CLAY + GRA. GRA ≤ 2" | SW | S-2 MOIST (4.0) |
| | 4 | 27 / 38 | 1.5 / 2.0 | | | | | | |
| S-3 1009 | | 23 / 26 | | | MED DENSE | BRN BLK | CLAYEY SILT SOME GRADED SAND | ML | S-3 MOIST (0.2) |
| | 6 | 15 / 13 | 1.4 / 2.0 | | | | | | |
| S-4 1017 | | 5 / 10 | | | LOOSE | BLK | SILTY CLAY W/ORGANICS | OL | S-4 MOIST WET AT 7.9' (0.0) |
| | 8 | 10 / 10 | 1.5 / 2.0 | | | | | | |
| S-5 1020 | | 7 / 7 | | | LOOSE | BLK to GRN | Clay, BLK at 8.5; [illegible] 9.0, Green Some Silt at 9.5' | CH | Saturated at 8.5 |
| | 10 | 7 / 8 | 1.5 / 2.0 | | | | | | |
| | | | | | | | TD = 6' | | 2 HSA down hole |
| | | | | | | | SD = 10' STOPPED AT 10:24 | | AFTER 6'. DID NOT NEED |
| | | | | | | | Sat. @ 8.5' | | TO AUGER FROM 6' to 8 |

REMARKS: CENTER BID 4 1/4 H.S.A. 2 1/4 ID SPLITSPOON w/ [illegible] INSERTS.
140 lb HAMMER DROP 30 inches
Asphalt 6" thick
COMPOSITE SAMPLE

* CAPPED INSERTS INDICATED BY ✓.

BORING SB004-PS2
PAGE ____

Source: HNUS, 1993

BORING LOG — NUS CORPORATION

PROJECT: FAFB
PROJECT NO.: 3286
ELEVATION:
WATER LEVEL DATA:
(Date, Time & Conditions) 11/3/91 10:45 35° F, CLOUDY

DATE: 11/3/91
FIELD GEOLOGIST: P. NIMMER / F. RAMSER

BORING NO. SB005 - PS2
DRILLER: THERON L. / BACT BROS

| SAMPLE NO & TYPE OR RQD | DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS SPLITSPOON HNu |
|---|---|---|---|---|---|---|---|---|---|
| S-1 1035 | | – / 42 | | | DENSE | BLK | ASPHALT ≈ FIRST 6" SILT AND FINE SAND | ML | DRY (0.5 |
| | 2 | 42 / 42 | 1.5 / 2.0 | | | | | | |
| S-2 11:00 | | 23 / 23 | | | MED. DENSE | BRN | CLAYEY SILT, SOME GRAVEL AND SAND AT NEAR 2-3' | CL | MOIST (4 PP |
| | 4 | 36 / 23 | 1.6 / 2.0 | | | | | | |
| S-3 1115 | | 8 / 12 | | | LOOSE TO MED DENSE | BRN - GRY | SILTY CLAY, SOME SAND. | ML | MOIST. (0-5 |
| | 6 | 50 | 1.3 / 1.5 | | | | | | REFUSAL AT 5.5' |

FINISH TIME: 11:22
TD: 5.5 SD: 5.5
$H_2O$ @: —

REMARKS: CANTERA RIB 4 1/4, 2 1/4 ID SPLIT SPOON W/ BRASS INSERTS.
140 lb HAMMER DROP 30 INCHES.
ASPHALT ≈ 6" THICK

BORING SB005-PS2
PAGE ___ OF ___

(*) CAPPED INSERTS INDICATE B-1

Source: HNUS, 1993

BORING LOG | NUS CORPORATION

PROJECT: FAFB | BORING NO: SB006 P-2

PROJECT NO.: 3286 | DATE: 11/1/91 | DRILLER: THERON L./BART BROS.

ELEVATION: | FIELD GEOLOGIST: FRED W. RAMSER

WATER LEVEL DATA:

(Date, Time & Conditions) 11/1/91 1100 CLEAR COLD 30°F WINDY

| SAMPLE NO & TYPE OR RQD | DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | MATERIAL DESCRIPTION: COLOR | MATERIAL DESCRIPTION: MATERIAL CLASSIFICATION | U S C S | REMARKS SPLITSPOON HNU → (ppm) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | BRN | ASPHALT ≈6" THICK BASE ≈1.5' THICK SILTY SAND | SM | |
| | 2 | | | | | D-BRN | SILT SAND | | |
| S-1 1111 | | 17 | | | | | SILTY SAND w/some CLAY & GRAVEL | SP | S-1 DUPLICATE) SLIGHTLY MOIST (0.7) |
| | | 39 | | | | | | | |
| | | 49 | 1.5 / 2.0 | | | | | | |
| | 4 | 27 | | | | | | | |
| (S-2) 1120 | | 9 | | | STIFF | BLK | SILTY CLAY w/some SAND | CL | S-2 MOIST (5.0) |
| | | 13 | | | | | | | |
| | | 15 | 1.5 / 2.0 | | | | | | |
| | 6 | 19 | | | | | | | |
| (S-3) 1135 | | 4 | | | STIFF | BLK | AS ABOVE | CL | S-3 MOIST (25) |
| | | 6 | | | | | | | |
| | | 6 | 1.3 / 2.0 | | | | | | |
| | 8 | 7 | | | | | | | |
| S-4 1140 | | 5 | | | | | AS ABOVE | CL | S-4 SATURATED @ 9' (5 |
| | | 15 | | | | | | | |
| | | 7 | 1.7 / 2.0 | | | GRN | GRADED SAND @ 9.5 TO 10.0' | SW | |
| | | 17 | | | | | | | |
| | | | | | | | TD = 8' SAMPLED TO 10' | | |
| | | | | | | | $H_2O$ @ 9' | | |

REMARKS CANTERA RIG 4¼" HSA, 2¼" S.S. w/BRASS INSERTS, 140 lb HAMMER DROPPED 30"

NOTE @ 6' MEASURED 25 ppm @ HEAD SPACE IN AUGER, MEASURED 0.0 ppm @ BZ.

(GOOD WINDS)

BORING SB006 PS2

PAGE 1

* CAPPED INSERTS ARE INDICATED WITH A CHECK MARK

CIRCLED SAMPLE # INDICATES SAMPLE SENT TO LAB FOR CHEMICAL ANALYSIS

Source: HNUS, 1993

BORING LOG — NUS CORPORATION

PROJECT: FAFB — BORING NO. SB007 PS-2

PROJECT NO.: 3286 — DATE: 10/31/91 — DRILLER: THERON L. / BART. BROS

ELEVATION: — FIELD GEOLOGIST: FRED KRAMSER

WATER LEVEL DATA:

(Date, Time & Conditions) 10/31/91 10 45 OVERCAST, FLURRIES COLD 35°F

| SAMPLE NO & TYPE OR ROD | ① DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈ 6" | | |
| S-1 10 52 | | 17 / 20 | | | VERY DENSE | GREY | SAND, SILT, FINE GRAVELS ≤.5" dia | SP | S-1 (22° ... MOIST |
| | 2 | 41 / 49 | 1.1 / 2.0 | | | | TR CLAY | | |
| S-2 11 10 | | 27 / 50/1" | | | VERY DENSE | GRN GREY | CLAYEY SILT w/some GRADED SAND TR GRAVEL ≤1.5 dia SUBROUND TO | SC | S-2 2'-2.5' ... |
| | 4 | 50/ | .7 / 2.0 | | | | ANGULAR AS ABOVE | | AUGER 6" HAMMER ... spoon @ 2.5 STILL SPOON REFUSAL, AUGER ... |
| S-3 11 24 | 4.5 | 17 / 17 | | | STIFF | D-GRN | CLAY, SOME SILT + GRADED SAND | CL | S-3 6" ROTARY ... AUGERED ... TO 4.5' HAMMER S.S. |
| | 6 | 18 / 20 | 1.5 / 2.0 | | | | | | S-3: 4.5-6.5 MOIST |
| S-4 11 35 | | 8 / 9 | | | MED DENSE | D-GRN | GRADED SAND w/SOME SILT + CLAY | SP | S-4 6.5-8.5 SATURATED (TOP) @ 8.4 |
| | 8 | 11 / 10 | 1.0 / 2.0 | | | | | | |

TD ≈ 6.5 SAMPLED TO 8.5'

$H_2O$ @ 8.4

COMPLETED AT 11.40

REMARKS CANTERA RIG 4¼ HSA 2½" ID S.S. w/BRASS INSERTS

SB007 COMPOSITE SAMPLE

① ZERO DEPTH @ 6" BELOW ASPHALT TOP SURFACE

BORING SB007 PS-

PAGE 1 of 1

* CAPPED INSERTS ARE INDICATED BY A CHECK MARK

CIRCLED SAMPLE # INDICATES SAMPLE SENT TO LAB FOR CHEMICAL ANALYSIS

TWO S.S. REF.

Source: HNUS, 1993

| BORING LOG | NUS CORPORATION |
|---|---|

PROJECT: FAFB BORING NO SB008, PS2
PROJECT NO.: 3286 DATE: 11/1/91 DRILLER: THERON L. / BARTH BROS.
ELEVATION: FIELD GEOLOGIST: FRED W PAMSER
WATER LEVEL DATA:
(Date, Time & Conditions) 11-1-91 0755 COLD 28°F WINDY CLEAR

| SAMPLE NO. & TYPE OR RQD | DEPTH (Ft.) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, Ft.) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS (MATERIAL DESCRIPTION) | COLOR (MATERIAL DESCRIPTION) | MATERIAL CLASSIFICATION (MATERIAL DESCRIPTION) | U S C S | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈6" | | SPLIT SPOON - HNU - [illegible] |
| S-1 1005 | | 50 | | | DENSE | BRN | SAND w/some SILT + GRAVEL ±.5" | SW | S-1 (0.5) SLIGHTLY MOIST |
| | | 50/6" | | | | | | | |
| | 2 | ↓ | 1.0 / 1.0 | | | | | | |
| S-2 1015 | | 60 | | | | | SILTY CLAY w/some SAND TR/GRAVEL ±.5" | CL | S-2 SLIGHTLY MOIST (0.5) |
| | | 70/6" | | | DENSE | D-BRN | | | |
| | 4 | ↓ | 0.9 / 1.0 | | | | | | |
| ✓ S-3 1030 | | 8 | | | STIFF | BLK | SILTY CLAY TR SAND + GRAVEL | CL | S-3 MOIST (5.[illegible] |
| | | 9 | | | | | | | |
| | | 9 | | | | | | | |
| | 6 | 12 | 1.3 / 2.0 | | | | | | |
| ✓ S-4 1040 | | 12 | | | STIFF | D-GRN | CLAYEY SILT w/some SAND + GRAVEL | MH | S-4 SATURATED AT 7.9 (5.[illegible] |
| | | 12 | | | | | | | |
| | | 12 | | | | | | | |
| | 8 | 12 | 1.5 / 2.0 | | MED DENSE | GRN | GRADED SAND @ 7.5 to 8.0' | SP | |
| | | | | | | | TD = 6" SAMPLED TO 8' | | |
| | | | | | | | $H_2O$ @ 7.9' | | |

REMARKS CANTERA RIG 4¼" HSA, 2½" S.S. w/BRASS INSERTS 140 lb HAMMER DROPPED 30"
① ZERO DEPTH @ 6" BELOW ASPHALT TOP SURFACE

BORING SB008 PS2

PAGE 1 (

* CAPPED INSERTS ARE INDICATED BY A CHECK MARK
CIRCLED SAMPLE # INDICATES SAMPLE TUBE SENT FOR ANALYSIS

Source: HNUS, 1993

# BORING LOG

**NUS CORPORATION**

PROJECT: FAFB
BORING NO SB009 PS-2

PROJECT NO.: 328G
DATE: 10-31-91
DRILLER: Theron L. / Bartholomew

ELEVATION:
FIELD GEOLOGIST: Fred W Ranser

WATER LEVEL DATA:
(Date, Time & Conditions) 10/31/91 1340 OVERCAST 32° BREEZY

| SAMPLE NO & TYPE OR RQD | ① DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | MATERIAL DESCRIPTION: SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS (Background HNU ...) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈ 6" | | SPLIT SPOON |
| S-1 1355 | | 17 / 46 | | | V STIFF TO HARD | | | | S-1 |
| | 2 | 48 / 49 | 1.0 / 2.0 | | | GREY BRN | SILTY GRADED SAND SOME GRAVEL TR CLAY | SW | |
| S-2 1405 | | 18 / 36 | | | V STIFF TO HARD | D-GRU | SILTY CLAY – SOME GRADED SAND + GRAVEL GR ≤ 1.5" dia | CL | S-2 AUGER REFUSAL @ 2' MOVED 3' TOWARD BLDG. |
| | 4 | 50/2" | 0.9 / 1.2 | | | | | | S-2, 2-3.2 |
| S-3 1410 | | 5 / 5 | | | STIFF | BLK | SILTY CLAY TR/GRADED SAND 5-5.5' | CL | S-3 MOIST TR/ORGANICS |
| | 6 | 6 / 10 | 1.2 / 2.0 | | | GRN BLK | GRADED SAND + SILT 5.5'-6.0' | SM | |
| S-4 1430 | | 6 / 6 | | | MED STIFF TO STIFF | GRU | GRADED SAND + SILT w/some GRAVEL ≤ .5" | SM | S-4 SATURATED @ 7.5 |
| | 8 | 8 / 12 | 1.2 / 2.0 | | | | | | |
| | | | | | | | TD = 6 SAMPLED TO 8.0' | | |
| | | | | | | | $H_2O$ @ 7.5 | | |

REMARKS CANTERA RIG 4¼" ID HSA, 2½" S.S. w/ BRASS INSERTS, 140 lb HAMMER DROPPED 30"
@ 4' HS @ GROUND LEVEL = 25 ppm
@ 4' B.Z. 0.0 ppm, GOOD BREEZE
① ZERO DEPTH @ 6" BELOW ASPHALT TOP SURFACE

BORING SB009
PAGE 1 of 1

* CAPPED INSERTS ARE INDICATED BY A CHECK MARK
CIRCLED SAMPLE # INDICATES SAMPLE SENT TO LAB FOR ANALYSIS

Source: HNUS, 1993

BORING LOG — NUS CORPORATION

PROJECT: FAFB — BORING NO ~~SB00~~ SB010 PS2
PROJECT NO.: 3286 — DATE: 11-1-91 — DRILLER: THERON L. BART. BROS.
ELEVATION: — FIELD GEOLOGIST: FRED WRAMSER
WATER LEVEL DATA:
(Date, Time & Conditions) 11-1-91 755 CLEAR, COLD 32° BREEZY

| SAMPLE NO. & TYPE OR ROD | ① DEPTH (FT) OR RUN NO. | BLOWS 6" OR RQD (%) | SAMPLE RECOVERY / SAMPLE LENGTH | LITHOLOGY CHANGE (Depth, ft.) OR SCREENED INTERVAL | SOIL DENSITY CONSISTENCY OR ROCK HARDNESS | COLOR | MATERIAL CLASSIFICATION | USCS | REMARKS |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ASPHALT ≈ 6" | | BACKGROUND HNU <0.6 ppm SPLIT SPOON HNU = (ppm) |
| S-1 0820 | | 39 / 18 / 20 / 20 | 1.9 / 2.0 | | MED DENSE | BRN | SILTY GRADED SAND w/some CLAY TR/GRAVEL | SM | S-1 GRAVEL ≤ 1.5" dia SLIGHTLY MOIST (0.2 |
| | 2 | | | | | | | | |
| S-2 0830 | | 17 / 20 / 27 / 28 | 1.4 / 2.0 | | | D.BRN | SILTY CLAY w/some GRAVEL ≤ 1.5" dia SUBANGULAR TO SUBROUNDED | CL | S-2 TR/ORGANICS SLIGHTLY MOIST (0.4 |
| | 4 | | | | | | | | |
| S-3 0845 | | 17 / 20 / 22 / 24 | 1.5 / 2.0 | | MED-D STIFF | D.BRN | SILTY GRADED SAND w/some CLAY 5.5-6 SILTY CLAY (4.5 to 5.5) TR/SAND + GRAVEL ≤ 1.0" dia | SM - CL | S-3 MOIST SLIGHTLY MOIST (0.0 |
| | 6 | | | | | | | | |
| S-4 0900 | | 16 / 16 / 16 / 10 | 1.5 / 2.0 | | MED DENSE | | GRADED SAND w/some SILT TR/CLAY | SM | S-4 SATURATED @ 7.5' (0.2 |
| | 8 | | | | | | | | |
| | | | | | | | TD = 6 SAMPLED to 8' | | |
| | | | | | | | $H_2O$ @ 7.5' | | |

REMARKS CANTERA RIG 4¼" HSA, 2¼" S.S. w/BRASS INSERTS, 140 lb HAMMER DROPPED 30"
① ZERO DEPTH @ 6" below ASPHALT TOPSURFACE

BORING SB010 PS

PAGE 1

* CAPPED INSERTS ARE INDICATED BY A CHECKMARK
CIRCLED SAMPLE # INDICATES SAMPLE TO BE SENT TO LAB FOR ANALYSIS

Source: HNUS, 1993

| BORING LOG | Boring/Well No.: VW-1 | | |
|---|---|---|---|
| Installation: FAIRCHILD AFB | | Site: PS 2 | Project No: [illegible] |
| Client/Project: AFCEE | Contractor: ENGINEERING - SCIENCE | | |
| Drilling Contractor: ENV WEST | Drillers: RICK McCARRELL & TED MAN | | |
| Drilling Started: () 9-22-93 | Drilling Ended: () 9-23-93 | OSHA Protection Level: D | |
| Drilling Method: AUGER | Sampling Method: SPLIT SPOON | Borehole dia (s): 11" | |
| Geologist: S THOMAS TAYLOR | Borehole Coordinates: | LS Altitude: | |

| DEPTH (feet) | RECOVERY (%) | HEAD SPACE Amount (ppm) | HEAD SPACE Interval (feet) | CHEMICAL SAMPLES No. | CHEMICAL SAMPLES Interval (feet) | LITHOLOGIC DESCRIPTION | GRAPHIC LOG | USCS SOIL CLASSIFICATION | WELL LOG DATA |
|---|---|---|---|---|---|---|---|---|---|
| | | [illegible] | [illegible] | | | 0-2' GRAVELLY SAND, GRAY N5-N6, VERY POORLY SORTED, ANGULAR, LOOSE UNCONSOLIDATED DAMP, FUEL ODOR, PROBABLY FILL MATERIAL | | | |
| | | [illegible] | 2.0 2.5 | | | 2'-2.5 SAND, DARK GREENISH-GRAY, WELL SORTED, MICACEOUS, DAMP, WELL ROUNDED, LOOSE-UNCONSOLIDATED, FUEL ODOR | | | |
| | | [illegible] | 3.0 3.5 | | | 2.5-3.0 SAND AS ABOVE WITH PEBBLY GRAVEL | | | |
| | | | | | | 3.0-6.0 AS ABOVE SAND & GRAVEL, MINOR CLAY | | | |
| 5 | | 3100 984 | 6.0-6.5 | | | 6.0-8.0 SAND AND GRAVEL, SILTY, MINOR, CLAY, DARK BROWN, POORLY ROUNDED, POORLY SORTED, DAMP FUEL ODOR, UNCONSOLIDATED | | | |
| | | 3600 1051 | 7.0-7.5 | PS-2-VW1-7.5 | 78-84" 90-96" 96-102" | 8.0-9.0 SAND AND SILT, VERY FINE GRAINED SAND, MINOR CLAY, DARK BROWN, WELL ROUNDED, WELL SORTED, DAMP WET, FUEL ODOR, UNCONSOLIDATED BUT COHESIVE | | | |
| 10 | | | | | | | | | |
| 15 | | | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |
| 30 | | | | | | | | | |

Source: ES, 1994

| BORING LOG | Boring/Well No.: VMP-1 | Site: PS-2 | Project No: DE268 |
|---|---|---|---|

Installation: FAIRCHILD AFB

Client/Project: AFCEE — Contractor: ENGINEERING-SCIENCE

Drilling Contractor: ENV WEST — Drillers: RICK McCORKLE & TED MAY

OSHA Protection Level: D

Drilling Started: 0 9-23-93 — Drilling Ended: 0 9-23-93 — Borehole dia (s): 8"

Drilling Method: AUGER — Sampling Method: SPLIT SPOON

LS Altitude:

Geologist: S. THOMAS TAYLOR — Borehole Coordinates:

| DEPTH (feet) | RECOVERY (%) | HEAD SPACE Amount (ppm) | HEAD SPACE Interval (feet) | CHEMICAL SAMPLES No. | CHEMICAL SAMPLES Interval (feet) | LITHOLOGIC DESCRIPTION | GRAPHIC LOG | USCS SOIL CLASSIFICATION | WELL LOG DATA |
|---|---|---|---|---|---|---|---|---|---|
| | | 2600 1062 | 0-6" | | | 0.0-2.0 GRAVELLY SAND, GRAY (N5-N6), VERY POORLY SORTED, ANGULAR, LOOSE-UNCONSOLIDATED, DAMP, FUEL ODOR, PROBABLY FILL MATERIAL | | 18 40 50 | |
| | | 8200 1453 | 24-27" | | | 2.0-2.5 SILT WITH VERY FINE-GRAINED SAND, BROWNISH-BLACK, WELL SORTED, DAMP, FUEL ODOR, FIRM | | 19 19 10 | ← 39" [illegible] REFUSAL |
| 5 | | 6200 1409 | 48-54" | PS2-VMP1-4 | 53-54 54-60 60-66 | 2.5-3.3 SAND, GREENISH GRAY, FINE-GRAINED, MINOR SILT, MOD. SORTING, MOD. ROUNDED, DAMP, FUEL ODOR | | 8 13 19 19 | |
| | | 3400 1026 | 72-78" | | | 3.3-5.5 SILTY SAND, SAND IS VERY FINE GRAINED, DARK BROWN, POORLY SORTED, POORLY ROUNDED, OCCASIONAL PEBBLES, DAMP, FUEL ODOR, UN-CONSOLIDATED. | | 7 26 40 55 | |
| | | 4200 1304 | 96-102 | | | 5.5-7.0 AS ABOVE BUT AVERAGE GRAIN SIZE INCREASING DOWNWARD | | 4 14 30 50 | |
| 10 | | | | | | 7.0-8.0 NOT RECOVERED | | | |
| | | | | | | 8.0-8.6 SILT AND CLAY, DARK BROWN, POSSIBLY ORGANIC RICH, WET, FIRM, FUEL ODOR | | | |
| | | | | | | 8.6-9.0 SAND, GRAY, COARSE GRAINED, WELL SORTED, POORLY ROUNDED, WET, FUEL ODOR, UNCONSOLIDATED | | | |
| 15 | | | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |
| 30 | | | | | | | | | |

Source: ES, 1994

| | | | |
|---|---|---|---|
| BORING LOG | Boring/Well No.: VMP-2 | Site: PS-2 | Project No: DE 268 |
| Installation: FAIRCHILD AFB | | | |
| Client/Project: AFCEE | Contractor: ENGINEERING - SCIENCE | | |
| Drilling Contractor: ENV. WEST | Drillers: RICK McCORKLE & TED MAY | | |
| Drilling Started: () 9-24-93 | Drilling Ended: () 9-24-93 | | OSHA Protection Level: D |
| Drilling Method: AUGER | Sampling Method: SPLIT SPOONS | | Borehole dia (s): 8" |
| | | | LS Altitude: |
| Geologist: S. THOMAS TAYLOR | Borehole Coordinates: | | |

| Depth (feet) | RECOVERY (%) | HEAD SPACE Amount (ppm) | HEAD SPACE Interval (feet) | CHEMICAL SAMPLES No. | CHEMICAL SAMPLES Interval (feet) | LITHOLOGIC DESCRIPTION | GRAPHIC LOG | USCS SOIL CLASSIFICATION Blows | WELL LOG DATA |
|---|---|---|---|---|---|---|---|---|---|
| | | 2700 689 | 0 - 0.5 | | | 0-2': 0-6" GRAVEL, GRAY, POORLY SORTED, ANGULAR, DAMP FUEL ODOR, UNCONSOLIDATED. 6-24" SAND, GRAY, MOD SORTING, MOD. ROUNDED, DAMP, FUEL ODOR UNCONSOLIDATED. WITH PERCENTAGE SILT INCREASING DOWNWARD | | [illegible] | |
| | | 10,000+ 924 | 2.0 - 2.5 | — | — | 2-4 SAND, SILTY, DARK BROWN, FINE GRAINED, MOD. ROUNDED MOD. SORTING, DAMP, FUEL ODOR, UNCONSOLIDATED SOME GRAVEL IN BOTTOM SIX INCHES (42-48"). | | [illegible] | |
| 5 | | 8300 1155 | 4.0 - 4.5 | PS2-VMP2-4 | 4.5 - 6.0 | 4-6 AS ABOVE WITH GRAIN SIZE DECREASING DOWNWARD, FUEL ODOR | | [illegible] | |
| | | 2900 981 | 6.0 - 6.1 | | | 6-7'2" VERY FINE GRAINED SAND AND SILT, ROUNDED MODERATE TO GOOD SORTING, DAMP, UNCONSOLIDATED FUEL ODOR. OCCASIONAL PEBBLES AND COBBLES | | 15 37 SC last 2" | |
| 10 | | | | | | T.D. 7'2" | | | |
| 15 | | | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |
| 30 | | | | | | | | | |

Source: ES, 1994

**BORING LOG** Boring/Well No.: VMP-3

| | | |
|---|---|---|
| Installation: FAIRCHILD AFB | Site: PS-2 | Project No: DC268 |
| Client/Project: AFCEE | Contractor: ENGINEERING-SCIENCE | |
| Drilling Contractor: ENV. WEST | Drillers: RICK McCORCLE & TED MAY | |
| Drilling Started: 9-28-93 | Drilling Ended: 9-28-93 | OSHA Protection Level: |
| Drilling Method: AUGER | Sampling Method: SPLIT SPOON | Borehole dia (s): 8" |
| Geologist: S. THOMAS TAYLOR | Borehole Coordinates: | LS Altitude: |

| DEPTH (feet) | RECOVERY (%) | HEAD SPACE Amount (ppm) | HEAD SPACE Interval (feet) | CHEMICAL SAMPLES No. | CHEMICAL SAMPLES Interval (feet) | LITHOLOGIC DESCRIPTION | GRAPHIC LOG | USCS SOIL CLASSIFICATION | WELL LOG DATA |
|---|---|---|---|---|---|---|---|---|---|
| | | <100 | 0-0.5 | | | 0-1' SAND, GRAY-GREEN COARSE GRAINED, MINOR SILT, POORLY ROUNDED, POORLY SORTED, DAMP, FUEL ODOR, UNCONSOLIDATED PROBABLY FILL, GRAVEL ALSO IN SAMPLE | | 17 50 | |
| | | | | | | 1-2' NO RECOVERY | | | |
| | | 6200 | 2.0-2.5 | | | 2-4 SAND AND SILT, COARSE GRAINED, VERY POORLY SORTED, OCCASIONAL PEBBLES, POORLY ROUNDED, DAMP, FUEL ODOR, UNCONSOLIDATED | | 21 22 25 30 | |
| | | 1000+ | 3.0-3.5 | | | | | | |
| 5 | | 1000+ | 4.5-5.0 | | | 4-6 SAND AND SILT AS ABOVE WITH 6" THICK LENSE OF CLEAN SAND AT 5' | | 7 15 26 35 | |
| | | 2900 | 5.5-6.0 | | | | | | |
| | | 2700 | 6.5-7.0 | | | 6-8 SILTY SAND AS ABOVE WITH SILT INCREASING DOWNWARD, FUEL ODOR (SLIGHTLY LESS STRONG THAN ABOVE). | | 5 5 8 20 | |
| | | 1150 | 7.5-8.0 | | | | | | |
| 10 | | | | | | | | | |
| 15 | | | | | | | | | |
| 20 | | | | | | | | | |
| 25 | | | | | | | | | |
| 30 | | | | | | | | | |

Source: ES, 1994

# WELL DRILLING LOG

| | | | | |
|---|---|---|---|---|
| PROJECT | FAFB 41584-504-07 | WELL ID. | MW-229 | PAGE 1 OF 2 |
| DATE(S) DRILLED | 11-14-94 | RIG TYPE | INGERSOL RAND A300/140# CORE DR. | |
| GEOLOGIST/ENGINEER | MITCH HALL | LOCATION | PS-2 | |
| GEOLOGIST/ENGINEER | JIM BUSH | WATER LEVEL | MOIST AT 5.5', SATURATED AT 8' | |
| DRILLING SUBCONTRACTOR | ENVIRONMENTAL WEST | TOTAL DEPTH OF HOLE | 16.5' | |

| DEPTH (ft) BGS AS DRILLED | RECOVERY (%) | BLOWS/6in. 140# HAMMER | BOREHOLE METER READING | SAMPLE ID. | SAMPLES | GENERAL LITHOLOGY | MATERIALS DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 0 | | | | | | SW | SW – AUGERED. MEDIUM SAND. DARK BROWN FILL. | CON-CRETE; RISER; PVC CASING |
| 1 | 100% | | | PS02229S01 | | | | |
| 2 | | | | | | | | BENT-ONITE |
| 3 | | | | | | | 3 ppm IN BOTTOM HALF. SILTY. SLIGHTLY CLAYEY MEDIUM SAND. MEDIUM BROWN. | |
| 4 | | | | | | | | SAND FILTER PACK |
| 5 | | 11 | | | | | | |
| 6 | | 15 | | | | | BOTTOM 2–4" WET IN CORE BARREL. BOTTOM 4" COARSE BASALTIC GREEN TO GRAY. GRANULAR SAND ~30% GRANULES. | PVC SCREEN |
| | | 22 | 2–3 ppm | | | SW | SW – UPPER 6" MIXED TWO PREVIOUS LITHOLOGIES (SLOUGH?). MIXED BASALTIC GRAVEL AND SAND. ~30% GRANULAR, ~30% COARSE SAND, ~30% PEBBLES. BOTTOM 1" VERY CLEAN, FINE SAND TO SILT. WET. | |
| 7 | | 16 | | | | | | |
| | | 23 | | | | | | |
| 8 (▽ water level) | | 21 | 3 ppm | | | | | |
| | | | Notable petroleum odor, 18 ppm | PS02229S02 | | | ALL WET (8' TO 9.5'). BASALTIC GRAVEL CONTINUED. SAMPLE = 24 ppm. | |
| 9 | | 15 | Notable petroleum odor, 20 ppm | | | | | |
| | | 14 | | | | CL | CL – STIFF CLAYEY SILT FROM 8'10" TO 11'2". SCATTERED SMALL GRAINS OF ROUNDED SAND (TRACE). LIGHT REDDISH-BROWN OVER ALL COLOR. | |
| | | 7 | | | | | | |
| 10 | | 11 | | | | | STA. CLAY BECOMING REDUCED. MOTTLED WITH PATCHES OF GRAY IN LOWER PORTION FROM ABOUT 10' DOWN. VERY UNIFORM CONSISTENCY. | |
| 11 | | 25 | 83 ppm | | | | | |
| | | 10 | | | | SW | SW – CORE = 0 ppm. UNIFORM VERY COARSE TO GRANULE SAND. NO ODOR., DOMINATELY BASALTIC. | |
| 12 | | 27 | | | | | | |
| | | 30 | | | | | | |
| 13 | | 3 | | | | | UNIFORM VERY COARSE SAND. VARIEGATED. EMPHASIZES BASALTIC COMPOSITION, WITH YELLOW, RED AND ORANGE GRAINS. | |
| | | 20 | | | | | | |
| 14 | | 35 | 3 ppm | | | | STOPPED SPLIT SPOON. AUGERED TO TOTAL DEPTH. SAND SIMILAR TO ABOVE OBSERVED ON AUGER PLUG TO 16'. | |
| 15 | | | | | | | | |

**Source: ICF, 1995**

DRAWING FILE: MW-229.dwg

# WELL DRILLING LOG

| | | | |
|---|---|---|---|
| PROJECT | FAFB 41534-504-07 | WELL ID. | MW-229 PAGE 2 OF 2 |
| DATE(S) DRILLED | 11-14-94 | RIG TYPE | INGERSOL RAND A300/140# C.D. |
| GEOLOGIST/ENGINEER | MITCH HALL | LOCATION | PS-2 |
| GEOLOGIST/ENGINEER | JIM BUSH | WATER LEVEL | MOIST AT 5.5', SATURATED AT 8' |
| DRILLING SUBCONTRACTOR | ENVIRONMENTAL WEST | TOTAL DEPTH OF HOLE | 16.5' |

| DEPTH (ft) BGS AS DRILLED | RECOVERY (%) | BLOWS/6in. 140# HAMMER | BORHOLE METER READING | SAMPLE ID. | SAMPLES | GENERAL LITHOLOGY | MATERIALS DESCRIPTION | WELL DIAGRAM |
|---|---|---|---|---|---|---|---|---|
| 15–16.5 | 100 | | | | | | SOME HEAVING SAND AT BOTTOM. (~1.5'-2' FROM BOTTOM) TOTAL DEPTH = 16.5' BELOW GROUND SURFACE AS DRILLED. | SAND FILTER PACK; SUMP CAP |
| | | | | | | | (6 BAGS SAND, 3 BAGS HOLE PLUG USED) | |
| 17 | | | | | | | | |
| 18 | | | | | | | | |
| 19 | | | | | | | | |
| 20 | | | | | | | | |
| 21 | | | | | | | | |
| 22 | | | | | | | | |
| 23 | | | | | | | | |
| 24 | | | | | | | | |
| 25 | | | | | | | | |
| 26 | | | | | | | | |
| 27 | | | | | | | | |
| 28 | | | | | | | | |
| 29 | | | | | | | | |
| 30 | | | | | | | | |

**Source: ICF, 1995**

DRAWING FILE: MW-229B.dwg

# APPENDIX B - 1b

# GROUNDWATER BTEX AND TPH RESULTS

Table 4-19. Historical Analytical Results for Groundwater - Site OU-1 Total Petroleum Hydrocarbons, and Volatile Organic Compounds

Fairchild AFB
Historical Analytical Results, Site OU-1
Groundwater Samples
Total Petroleum Hydrocarbons (ug/L), Common Anions (ug/L), Volatile Organic Compounds (ug/L)

| WELL NO. | SAMPLE NUMBER | AGENCY | SAMPLE DATE mm/dd/yy | TOTAL PETROLEUM HYDROCARBONS QUAL | 1,2-DICHLOROBENZENE QUAL | 1,3-DICHLOROBENZENE QUAL | 1,4-DICHLOROBENZENE QUAL | BENZENE 71-43-2 QUAL | ETHYL BENZENE 100-41-4 QUAL | TOLUENE 108-88-3 QUAL |
|---|---|---|---|---|---|---|---|---|---|---|
| MW-30 | GN-86-0202 | DOD | 11/18/86 | 2.7 J | 34.2 | 0.4 U | 619 | 4.8 | 28.7 | 1.5 |
| MW-30 | GN-87-0302 | DOD | 11/19/87 | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 | 0.5 U | 1.6 |
| MW-30 | PS8-GW-MW30-003 | DOD | 04/18/89 | 4.9 J | 5 U | 5 U | 5 U | 17 | 5 U | 5 UR |
| MW-30 | PS8-GW-MW30-004D | DOD | 04/18/89 | 1.3 J | 25 U | 25 U | 25 U | 41 | 440 | 33 R |
| MW-30 | PS8-GW-MW30-005 | DOD | 07/26/89 | 1.8 J | 5 U | 5 U | 5 U | 26 | 300 | 32 R |
| MW-31 | GN-86-0204 | DOD | 11/18/86 | 5.9 J | 48 | 136 | 700 | 198 | 348 | 46.1 |
| MW-31 | GN-87-0304 | DOD | 11/20/87 | 0.5 U | 10 U | 10 U | 410 | 27 | 10 U | 10 U |
| MW-31 | GN-87-0354D | DOD | 11/20/87 | 0.5 U | 13 U | 13 U | 420 | 65 | 13 U | 13 U |
| MW-31 | PS8-GW-MW31-003 | DOD | 04/18/89 | 0.3 J | 25 U | 25 U | 25 U | 25 U | 1300 | 0.5 UR |
| MW-31 | PS8-GW-MW31-004 | DOD | 07/25/89 | 5.4 J | 25 U | 25 U | 25 U | 25 U | 590 | 140 R |
| MW-31 | PS8-GW-MW31-005D | DOD | 07/25/89 | 4.9 J | 25 U | 25 U | 25 U | 25 U | 530 | 130 R |
| MW-32 | GN-86-0203 | DOD | 11/18/86 | 1 U | 0.4 U | 0.4 U | 0.3 U | 0.2 U | 0.2 U | 0.2 U |
| MW-32 | PS8-GW-MW32-002 | DOD | 04/18/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.6 R |
| MW-55 | PS2-GW-MW55-001 | DOD | 04/25/89 | 0.8 J | 5 U | 5 U | 5 U | 16 | 19 | 1.6 JR |
| MW-55 | PS2-GW-MW55-002D | DOD | 04/25/89 | 0.6 J | 5 U | 5 U | 5 U | 14 | 21 | 6 R |
| MW-55 | PS2-GW-MW55-003 | DOD | 07/25/89 | 0.6 J | 0.5 U | 0.5 U | 0.5 U | 29 | 35 | 0.6 JR |
| MW-56 | PS2-GW-MW56-001 | DOD | 04/25/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 3.6 JR |
| MW-56 | PS2-GW-MW56-002 | DOD | 07/25/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 12 R |
| MW-56 | PS2-GW-MW56-003D | DOD | 07/25/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 UR |
| MW-66 | PS8-GW-MW66-001 | DOD | 04/26/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.2 R |
| MW-66 | PS8-GW-MW66-002 | DOD | 07/25/89 | 0.2 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 0.5 U | 13 R |
| MW-67 | PS8-GW-MW67-001 | DOD | 04/25/89 | 0.5 J | 5 U | 5 U | 5 U | 5 U | 430 | 27 R |
| MW-67 | PS8-GW-MW67-002 | DOD | 07/26/89 | 3.7 J | 25 U | 25 U | 25 U | 25 U | 410 | 25 R |
| MW-68 | PS8-GW-MW68-001 | DOD | 04/25/89 | 0.3 J | 5 U | 5 U | 5 U | 5 U | 320 | 5 UR |
| MW-68 | PS8-GW-MW68-002 | DOD | 07/25/89 | 1.8 J | 5 U | 5 U | 5 U | 5 U | 150 | 5 UR |

Source: SAIC, 1990

Table 4-19. Historical Analytical Results for Groundwater - Site OU-1 Total Petroleum Hydrocarbons, and Volatile Organic Compounds
(Continued)

Fairchild AFB
Historical Analytical Results, Site OU-1
Groundwater Samples
Total Petroleum Hydrocarbons (ug/L), Common Anions (ug/L), Volatile Organic Compounds (ug/L)

| WELL NO. | SAMPLE NUMBER | AGENCY | SAMPLE DATE mm/dd/yy | XYLENES (TOTAL) 1330-20-7 | QUAL | P-XYLENE | QUAL | M-XYLENE | QUAL | O-XYLENE | QUAL |
|---|---|---|---|---|---|---|---|---|---|---|---|
| MW-30 | GN-86-0202 | DOD | 11/18/86 | | | 38.3 | | 49.8 | | 78.5 | |
| MW-30 | GN-87-0302 | DOD | 11/19/87 | 260 | | | | | | | |
| MW-30 | PS8-GW-MW30-003 | DOD | 04/18/89 | 530 | | | | | | | |
| MW-30 | PS8-GW-MW30-004D | DOD | 04/18/89 | 1100 | | | | | | | |
| MW-30 | PS8-GW-MW30-005 | DOD | 07/26/89 | 820 | | | | | | | |
| MW-31 | GN-86-0204 | DOD | 11/18/86 | | | 0.3 | U | 3150 | | 1180 | |
| MW-31 | GN-87-0304 | DOD | 11/20/87 | 1800 | | | | | | | |
| MW-31 | GN-87-0354D | DOD | 11/20/87 | 2300 | | | | | | | |
| MW-31 | PS8-GW-MW31-003 | DOD | 04/18/89 | 4400 | | | | | | | |
| MW-31 | PS8-GW-MW31-004 | DOD | 07/25/89 | 3400 | | | | | | | |
| MW-31 | PS8-GW-MW31-005D | DOD | 07/25/89 | 3000 | | | | | | | |
| MW-32 | GN-86-0203 | DOD | 11/18/86 | | | 0.3 | U | 0.3 | U | 0.3 | U |
| MW-32 | PS8-GW-MW32-002 | DOD | 04/18/89 | 1 | U | | | | | | |
| MW-55 | PS2-GW-MW55-001 | DOD | 04/25/89 | 72 | | | | | | | |
| MW-55 | PS2-GW-MW55-002D | DOD | 04/25/89 | 72 | | | | | | | |
| MW-55 | PS2-GW-MW55-003 | DOD | 07/25/89 | 150 | | | | | | | |
| MW-56 | PS2-GW-MW56-001 | DOD | 04/25/89 | 1 | U | | | | | | |
| MW-56 | PS2-GW-MW56-002 | DOD | 07/25/89 | 1 | U | | | | | | |
| MW-56 | PS2-GW-MW56-003D | DOD | 07/25/89 | 1 | U | | | | | | |
| MW-66 | PS8-GW-MW66-001 | DOD | 04/26/89 | 1 | U | | | | | | |
| MW-66 | PS8-GW-MW66-002 | DOD | 07/25/89 | 1 | U | | | | | | |
| MW-67 | PS8-GW-MW67-001 | DOD | 04/25/89 | 1900 | | | | | | | |
| MW-67 | PS8-GW-MW67-002 | DOD | 07/26/89 | 1600 | | | | | | | |
| MW-68 | PS8-GW-MW68-001 | DOD | 04/25/89 | 960 | | | | | | | |
| MW-68 | PS8-GW-MW68-002 | DOD | 07/25/89 | 470 | | | | | | | |

Source: SAIC, 1990

TABLE K-3.6

TOTAL PETROLEUM HYDROCARBON AND VOLATILE ORGANIC CHEMICAL MONITORING DATA
SITE PS-2
FAIRCHILD AFB, WASHINGTON

| Monitoring Well | Sampling Round | | | | | | |
|---|---|---|---|---|---|---|---|
| | R3 | R4 | R6 | R7 | R8 | R9 | R11 |
| **UPGRADIENT WELL** | | | | | | | |
| 56 | NCD | NCD | NCD | NCD | | | NCD |
| **DOWNGRADIENT ALLUVIAL MONITORING WELLS** | | | | | | | |
| 55 | TPH = 6.8 mg/L<br>B = 15<br>EB = 21<br>X = 72 | TPH = 0.6 mg/L<br>B = 29<br>EB = 35<br>X = 150 | TPH = 2 mg/L<br>B = 12<br>EB = 12 | B = 53<br>EB = 180<br>X = 270 | | | B = 10<br>EB = 13<br>X = 25 |
| 105 | | | | | NCD | NCD | |
| 106 | | | | | NCD | NCD | EB = 5<br>X = 12 |
| 109 | | | | | TPH = 16 mg/L<br>B = 150<br>EB = 530<br>X = 1,200 | TPH = 6.8 mg/L<br>B = 34<br>X = 290 | TPH = 4.4<br>B = 40<br>EB = 190<br>X = 420 |
| 110 | | | | | CB = 4 | CB = 2 | CB = 18 |
| 176 | | | | | | | TPH = 110<br>B = 2,600<br>EB = 1,200<br>X = 5,000 |
| 177 | | | | | | | TPH = 27<br>B = 240<br>EB = 520<br>X = 2,200 |
| **DOWNGRADIENT BASALT A MONITORING WELLS** | | | | | | | |
| 178 | | | | | | | B = 7<br>EB = 11<br>X = 40 |
| 180 | | | | | | | NCD |

NCD No VOCs detected

B Benzene (µg/L)
CB Chlorobenzene (µg/L)
EB Ethylbenzene (µg/L)
X Xylenes (µg/L)
TPH Total Petroleum Hydrocarbons (mg/L)

Source: HNUS, 1993

TABLE 3-6

QUARTERLY OVERBURDEN AQUIFER, GROUNDWATER SAMPLE RESULTS ($\mu g/L$)
AUGUST 1994
FLOATING FREE-PRODUCT RECOVERY TREATABILITY STUDY
ON-BASE PRIORITY ONE OPERABLE UNIT, FLIGHTLINE OPERABLE UNIT, SITE PS-2
FAIRCHILD AIR FORCE BASE, WASHINGTON

| Analyte | MW-55 | MW-110 | MW-176 | MW-177 | MW-177A | MW-177B* |
|---|---|---|---|---|---|---|
| Benzene | 20 | 5 U | 1200 | 120 U | 5 U | 5 U |
| Toluene | 5 U | 5 U | 2500 | 120 U | 5 U | 5 U |
| Ethylbenzene | 31 | 5 U | 580 | 590 | 5 U | 5 U |
| m/p Xylenes | 8 | 5 U | 2000 | 2400 | 5 U | 5 U |
| o-Xylene | 5 U | 5 U | 2500 | 120 U | 5 U | 5 U |

| Analyte | MW-222 | MW-224 | MW-228 | MW-228A | MW-228B | MW-228C** |
|---|---|---|---|---|---|---|
| Benzene | 44 | 11 | 220 | 410 | 67 | 66 |
| Toluene | 5 U | 5 U | 120 U | 250 U | 5 U | 5 U |
| Ethylbenzene | 14 | 94 | 240 | 430 | 67 | 68 |
| m/p Xylenes | 9 | 38 | 970 | 2000 | 190 | 180 |
| o-Xylene | 5 U | 5 U | 120 U | 250 U | 7 | 7 |

* Duplicate sample from MW-177A.
** Duplicate sample from MW-228B.

**Source: HNUS, 1994**

TABLE 3-5

AUGUST 1994 QUARTERLY GROUNDWATER SAMPLING RESULTS ($\mu g/L$)
FLOATING FREE-PRODUCT RECOVERY TREATABILITY STUDY
ON-BASE PRIORITY ONE OPERABLE UNIT, FLIGHTLINE OPERABLE UNIT
FAIRCHILD AIR FORCE BASE, WASHINGTON

| | Gasoline Petroleum Hydrocarbons | Diesel Petroleum Hydrocarbons |
|---|---|---|
| MW-55 | 890 J | 200 |
| MW-110 | 260 J | 100 U |
| MW-176 | 25,000 J | 100,000 |
| MW-177 | 11,000 J | 7,800 J |
| MW-177A | 360 J | 100 U |
| MW-177B* | 550 J | 100 U |
| MW-222 | 6905 | 1000 |
| MW-224 | 1,400 J | 830 J |
| MW-228 | 25,000 J | 100,000 J |
| MW-228A | 490,000 J | 190,000 J |
| MW-228B | 1,600 J | 770 |
| MW-228C** | 2,100 J | 710 |

* Duplicate sample from MW-177A.
** Duplicate sample from MW-228B.

Source: HNUS, 1994

TABLE 3-6

QUARTERLY OVERBURDEN AQUIFER, GROUNDWATER SAMPLE RESULTS ($\mu g/L$)
NOVEMBER 1994
FLOATING FREE-PRODUCT RECOVERY TREATABILITY STUDY
ON-BASE PRIORITY ONE OPERABLE UNIT, FLIGHTLINE OPERABLE UNIT, SITE PS-2
FAIRCHILD AIR FORCE BASE, WASHINGTON

| Analyte | MW-55 | MW-109 | MW-110 | MW-176 | MW-177 | MW-177A |
|---|---|---|---|---|---|---|
| Benzene | 8 | 12 | 5 U | 2100 | 100 U | 5 |
| Toluene | 5 U | 5 U | 5 U | 500 U | 100 U | 5 U |
| Ethylbenzene | 12 | 550 | 5 U | 2400 | 420 | 5 U |
| m/p Xylenes | 5 UJ | 930 J | 5 U | 11,000 | 1900 | 5 J |
| o-Xylene | 5 U | 5 U | 5 U | 500 U | 100 U | 5 U |
| Chlorobenzene | 5 U | 5 U | 44 | 500 U | 100 U | 5 U |

| Analyte | MW-222 | MW-224 | MW-228 | MW-228A | MW-228B |
|---|---|---|---|---|---|
| Benzene | 79 | 52 | 490 | 2000 | 28 J |
| Toluene | 5 U | 5 U | 83 U | 250 U | 5 U |
| Ethylbenzene | 26 | 140 | 420 | 1400 | 22 J |
| m/p Xylenes | 5 U | 180 | 2000 | 5400 | 77 J |
| o-Xylene | 5 U | 5 U | 83 U | 250 U | 5 U |
| Chlorobenzene | 5 U | 5 U | 83 U | 250 U | 5 U |

**Source: HNUS, 1995b**

TABLE 3-5

NOVEMBER 1994 QUARTERLY GROUNDWATER SAMPLING RESULTS ($\mu g/L$)
FLOATING FREE-PRODUCT RECOVERY TREATABILITY STUDY
ON-BASE PRIORITY ONE OPERABLE UNIT, FLIGHTLINE OPERABLE UNIT
FAIRCHILD AIR FORCE BASE, WASHINGTON

| | Gasoline Petroleum Hydrocarbons | Diesel Petroleum Hydrocarbons |
|---|---|---|
| MW-55 | 120 | 250 U |
| MW-109 | 4800 | 2,100 |
| MW-110 | 200 | 250 U |
| MW-176 | 22,000 | 75,000 |
| MW-177 | 11,000 | 13,000 J |
| MW-177A | 270 | 250 U |
| MW-222 | 8500 | 380 |
| MW-224 | 1900 | 1100 |
| MW-228 | 31,000 | 54,000 |
| MW-228A | 45,000 | 110,000 |
| MW-228B | 1300 | 400 |

**Source: HNUS, 1995b**

## TABLE 4-2. SUMMARY OF PURGEABLE AROMATIC VOLATILE ORGANICS (SW5030/SW8020) LABORATORY ANALYSIS OF SAMPLES COLLECTED AT PS-2 IN NOVEMBER 1994

| PARAMETERS | PRACTICAL QUANTITATION LIMIT | ENVIRONMENTAL SAMPLE | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | 55 | | 56 | | 105 | 109 | | 110 | |
| | | PS02055W22[1] | PS02055W22[2] | PS02056W23 | PS02357W32[3] | PS02105W24 | PS02109W25 | PS02109W25[2] | PS02110W26 | PS02110W26[2] |
| | | 108467-0004-SA | 108467-0004-SA | 108467-0005-SA | 108467-0010-SA | 108467-0006-SA | 108467-0007-SA | 108467-0007-SA | 108467-0008-SA | 108467-0008-SA |
| **LABORATORY ANALYSIS[4]** | | | | | | | | | | |
| Benzene | 0.50 µg/L | 11.0 µg/L | 10 µg/L | 0.50 U µg/L | 0.50 U µg/L | 0.50 µg/L | 10 U µg/L | 10 U µg/L | 2.7 µg/L | 1.8 µg/L |
| Toluene | 1.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 20 U µg/L | 20 U µg/L | 2.5 µg/L | 1.3 µg/L |
| Ethylbenzene | 1.0 µg/L | 18 µg/L | 18 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 530 µg/L | 380 µg/L | 1.0 U µg/L | 1.0 U µg/L |
| Xylenes, Total | 1.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 780 µg/L | 670 µg/L | 26 µg/L | 22.0 µg/L |
| Surrogate Bromofluorobenzene | 29-137% | 86% | 86% | 101% | 106% | 100% | 99% | 90% | 97% | 91% |
| Diesel Fuel #2 | 0.50 mg/L | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Jet Fuel | 0.50 mg/L | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Unknown Hydrocarbon | 0.50 mg/L | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| Surrogate o-Terphenyl | 75-125% | NA | NA | NA | NA | NA | NA | NA | NA | NA |
| **FIELD ANALYSIS[5]** | | | | | | | | | | |
| Conductivity | 0-50,000 umhos/cm | 550 umhos/cm | 550 umhos/cm | 480 umhos/cm | 480 umhos/cm | 800 umhos/cm | 550 umhos/cm | 550 umhos/cm | 850 umhos/cm | 850 umhos/cm |
| pH | 1-14 | 6.88 | 6.88 | 6.55 | 6.55 | 6.87 | 6.69 | 6.69 | 6.85 | 6.85 |
| Temperature | 0-100°C | 11°C | 11°C | 13°C | 13°C | 8°C | 11°C | 11°C | 10°C | 10°C |
| Turbidity | 0-1,000 NTU | 287 NTU | 287 NTU | 762 NTU | 762 NTU | 404 NTU | 284 NTU | 284 NTU | 255 NTU | 255 NTU |

Source: ICF, 1995

## LE 4-2. SUMMARY OF PURGEABLE AROMATIC VOLATILE ORGANICS (SW5030/SW8020) LABORATORY ANALYSIS OF SAMPLES COLLECTED AT PS-2 IN NOVEMBER 1994 (Continued)

| PARAMETERS | PRACTICAL QUANTITATION LIMIT | ENVIRONMENTAL SAMPLE 176 PS02178W27 | 179 PS02179W28 | 180 PS02180W29 | 229 PS02229W30 | PS02229W30[2] | 230 PS02230W31 | PS02230W31[2] | PS02531W32[6] |
|---|---|---|---|---|---|---|---|---|---|
| | | 108781-0001-SA | 108781-0002-SA | 108467-0009-SA | 108781-0003-SA | 108781-0003-SA | 108838-0002-SA | 108838-0002-SA | 108838-0003-SA |
| LABORATORY ANALYSIS | | | | | | | | | |
| Benzene | 0.50 µg/L | 1.0 U µg/L | 1.0 U µg/L | 0.50 U µg/L | 3.2 µg/L | 1.6 µg/L | 0.50 U µg/L | 0.50 U µg/L | NA |
| Toluene | 1.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 3.8 µg/L | 3.2 µg/L | 1.0 U µg/L | 1.0 U µg/L | NA |
| Ethylbenzene | 1.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 21 µg/L | 14 µg/L | 2.7 µg/L | 3.7 µg/L | NA |
| Xylenes, Total | 1.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 7.4 µg/L | 8.0 µg/L | 1.0 U µg/L | 1.0 U µg/L | NA |
| Surrogate Bromofluorobenzene | 29-137% | 92% | 100% | 100% | 116% | 102% | 130% | 106% | NA |
| Diesel Fuel #2 | 0.50 mg/L | NA | NA | NA | 0.50 U mg/L | NA | 0.50 U mg/L | NA | 0.50 U mg/L |
| Jet Fuel | 0.50 mg/L | NA | NA | NA | 0.50 U mg/L | NA | 0.50 U mg/L | NA | 0.50 U mg/L |
| Unknown Hydrocarbon | 0.50 mg/L | NA | NA | NA | 0.87 mg/L y | NA | 0.50 mg/L y | NA | 0.53 mg/L y |
| Surrogate o-Terphenyl | 75-125% | NA | NA | NA | 88% | NA | 100% | NA | 116% |
| FIELD ANALYSIS | | | | | | | | | |
| Conductivity | 0-50,000 umhos/cm | 415 umhos/cm | 180 umhos/cm | 180 umhos/cm | 625 umhos/cm | 625 umhos/cm | 650 umhos/cm | 650 umhos/cm | 650 umhos/cm |
| pH | 1-14 | 6.79 | 7.91 | 7.67 | 8.22 | 8.22 | 7.02 | 7.02 | 7.02 |
| Temperature | 0-100°C | 11°C | 10°C | 14°C | 11°C | 11°C | 11.5°C | 11.5°C | 11.5°C |
| Turbidity | 0-1,000 NTU[4] | 105 NTU | 963 NTU | 142 NTU | 87.2 NTU | 87.2 NTU | 171 NTU | 171 NTU | 171 NTU |

Source: ICF, 1995

Table A-1
Analytical Results

Base: Fairchild AFB
Site: PS-2
Method Extraction: WTPH-D
Method Analytical: WTPH-D
Matrix: groundwater
Units: µg/L
Data Validation SDG: 950433

Contract No.: F41624-94-D-8052
Delivery Order: 12

| | | | Environmental Samples | | | Field blanks | | | Method blanks |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | PQL | Action Level* | Field ID Lab ID Column 1 | Field ID Lab ID Column 2 | Field ID Lab ID Primary | Trip Field ID Lab ID | Equip Field ID Lab ID | Ambient Field ID Lab ID | Field ID Lab ID |
| TPH-Diesel | 500 | 1000 | | | 0495PS2MW109<br>9504181<br>3900 | | | | |
| TPH-Diesel | 500 | 1000 | | | 0495PS2MW109A<br>9504182<br>5300 | | | | |
| TPH-Diesel | 500 | 1000 | | | 0495PS2MW179<br>9504183<br>270 | | | | |
| TPH-Diesel | 500 | 1000 | | | 0495PS2MW178<br>9504184<br>270 | | | | |
| TPH-Diesel | 500 | 1000 | | | 0495PS2MW110<br>9504189<br>720 | | | | |

Surrogate:Octacosane, Limits 50-150

**Source: ES&T AND MWA, 1995**

* Numeric action level values from ROD
** Action level not specified in ROD

## Table A
## Analytical Results

Base: Fairchild AFB
Site: PS-2
Method Extraction: not applicable
Method Analytical: 8020
Matrix: groundwater
Units: ug/L
Data Validation SDG: 950433

Contract No.: F41624-94-D-8052
Delivery Order: 12

| Parameters | PQL | Action Level* | Environmental Samples: Field ID / Lab ID / Column 1 | Environmental Samples: Field ID / Lab ID / Column 2 | Environmental Samples: Field ID / Lab ID / Primary | Field blanks: Trip / Field ID / Lab ID | Field blanks: Equip / Field ID / Lab ID | Field blanks: Ambient / Field ID / Lab ID | Method blanks: Field ID / Lab ID |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0495PS2MW55 | | | | |
| | | | | | 9504188F | | | | |
| Benzene | 1 | 5 | | | 16 | | | | |
| Ethylbenzene | 1 | ** | | | 19 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 1.7 | | | | |
| | | | | | 0495PS2MW110 | | | | |
| | | | | | 9504189F | | | | |
| Benzene | 1 | 5 | | | 2.2 | | | | |
| Chlorobenzene | 1 | ** | | | 2.1 | | | | |
| Ethylbenzene | 1 | ** | | | 3.0 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 1.0 | | | | |

Surrogate: bromofluorobenzene, Limits 69-126

**Source: ES&T AND MWA, 1995**

* Numeric action level values from ROD
** Action level not specified in ROD

Table A-1
Analytical Results

Base: Fairchild AFB
Site: PS-2
Method Extraction: not applicable
Method Analytical: 8020
Matrix: groundwater
Units: ug/L
Data Validation SDG: 950433

Contract No.: F41624-94-D-8052
Delivery Order: 12

| Parameters | PQL | Action Level* | Environmental Samples: Field ID Lab ID Column 1 | Environmental Samples: Field ID Lab ID Column 2 | Environmental Samples: Field ID Lab ID Primary | Field blanks: Trip Field ID Lab ID | Field blanks: Equip Field ID Lab ID | Field blanks: Ambient Field ID Lab ID | Method blanks: Field ID Lab ID |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | 0495PS2MW109A | | | | |
| | | | | | 9504182 | | | | |
| Benzene | 1 | 5 | | | 21 | | | | |
| Toluene | 1 | ** | | | 1.2 | | | | |
| Ethylbenzene | 1 | ** | | | 120 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 150 | | | | |
| Ortho Xylenes | 1 | ** | | | 2.6 | | | | |
| 1,3-Dichlorobenzene | 1 | ** | | | 17 | | | | |
| 1,4-Dichlorobenzene | 1 | ** | | | 14 | | | | |
| 1,2-Dichlorobenzene | 1 | ** | | | 37 | | | | |
| | | | | | 0495PS2MW178 | | | | |
| | | | | | 9504184 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 1.3 | | | | |
| | | | | | 0495PS2MW180 | | | | |
| | | | | | 9504186 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 1.7 | | | | |

**Source: ES&T AND MWA, 1995**

* Numeric action level values from ROD
** Action level not specified in ROD

## Table A-1
## Analytical Results

Base: Fairchild AFB
Site: PS-2
Method Extraction: not applicable
Method Analytical: 8020
Matrix: groundwater
Units: ug/L
Data Validation SDG: 950433

Contract No.: F41624-94-D-8052
Delivery Order: 12

| | | | Environmental Samples | | | Field blanks | | | Method blanks |
|---|---|---|---|---|---|---|---|---|---|
| Parameters | PQL | Action Level* | Field ID Lab ID Column 1 | Field ID Lab ID Column 2 | Field ID Lab ID Primary | Trip Field ID Lab ID | Equip Field ID Lab ID | Ambient Field ID Lab ID | Field ID Lab ID |
| | | | | | | 0495PS2FTB1 | | | |
| | | | | | | 9504187F | | | |
| Toluene | 1 | ** | | | | 5.2 | | | |
| | | | | | 0495PS2MW109 | | | | |
| | | | | | 9504181 | | | | |
| Benzene | 1 | 5 | | | 23 | | | | |
| Toluene | 1 | ** | | | 2.2 | | | | |
| Ethylbenzene | 1 | ** | | | 160 | | | | |
| Meta & Para Xylenes | 1 | ** | | | 170 | | | | |
| Ortho Xylenes | 1 | ** | | | 54 | | | | |
| 1,3-Dichlorobenzene | 1 | ** | | | 76 | | | | |
| 1,4-Dichlorobenzene | 1 | ** | | | 38 | | | | |
| 1,2-Dichlorobenzene | 1 | ** | | | 33 | | | | |

Source: **ES&T AND MWA, 1995**

* Numeric action level values from ROD
** Action level not specified in ROD

# APPENDIX B - 1c

# LNAPL MEASUREMENT RESULTS

R11 sampling event and during the March 1992 round of water level measurements. The depths of the floating products were measured as follows:

| Well Number and Date | Floating Product Thickness(1) (Feet) | Depth to Product(2) (Feet from ground surface) |
|---|---|---|
| MW176 01/09/92 | 0.17 | 8.57 |
| MW176 04/02/92 | 0.18 | 8.68 |
| MW177 01/09/92 | 0.55 | 7.40 |
| MW177 04/02/92 | 1.44 | 7.55 |

(1) Product thickness measured with clear bailer.
(2) Depth to product calculated by measuring depth to $H_2O$ with an M-Scope and subtracting product thickness.

**Source: HNUS, 1993**

TABLE 3-1 (Continued)
OVERBURDEN AQUIFER AND FLOATING FREE-PRODUCT ELEVATIONS AND RECOVERY
FLOATING FREE-PRODUCT RECOVERY TREATABILITY STUDY
ON-BASE PRIORITY ONE OPERABLE UNIT, FLIGHTLINE OPERABLE UNIT, SITE PS-2
FAIRCHILD AIR FORCE BASE, WASHINGTON

| Monitoring Well | Water Level (feet above mean sea level) | Floating Free-Product Level (feet above mean sea level) | Floating Free Product Recovered |
|---|---|---|---|
| DECEMBER 27, 1994 | | | |
| MW-55 | 2432.64 | None observed. | No recovery attempted. |
| MW-56 | 2434.41 | None observed. | No recovery attempted. |
| MW-105 | No elevation data. | None observed. | No recovery attempted. |
| MW-106 | No elevation data. | None observed. | No recovery attempted. |
| MW-109 | 2433.72 | None observed. | No recovery attempted. |
| MW-110 | 2433.64 | None observed. | No recovery attempted. |
| MW-176 | 2431.51 | None observed. | No recovery attempted. |
| MW-177 | 2433.98 | None observed. | Adsorbent wick replaced. |
| MW-177A | 2434.14 | None observed. | No recovery attempted. |
| MW-178 | 2434.12 | None observed. | No recovery attempted. |
| MW-179 | 2413.13 | None observed. | No recovery attempted. |
| MW-180 | 2428.92 | None observed. | No recovery attempted. |
| MW-222 | 2430.78 | None observed. | No recovery attempted. |
| MW-223 | 2431.51 | None observed. | No recovery attempted. |
| MW-224 | 2431.60 | None observed. | No recovery attempted. |
| MW-228 | 2431.25 | 2431.56 | 2000 ml FFP/water<br>7700 ml FFP |
| MW-228A | * | * | No recovery attempted. |
| MW-228B | 2431.51 | None observed. | No recovery attempted. |

* Billings corporation canister installed in MW-228A.

**Source: HNUS, 1995b**

# APPENDIX B - 1d

## SOIL & SOIL GAS BTEX AND TPH RESULTS

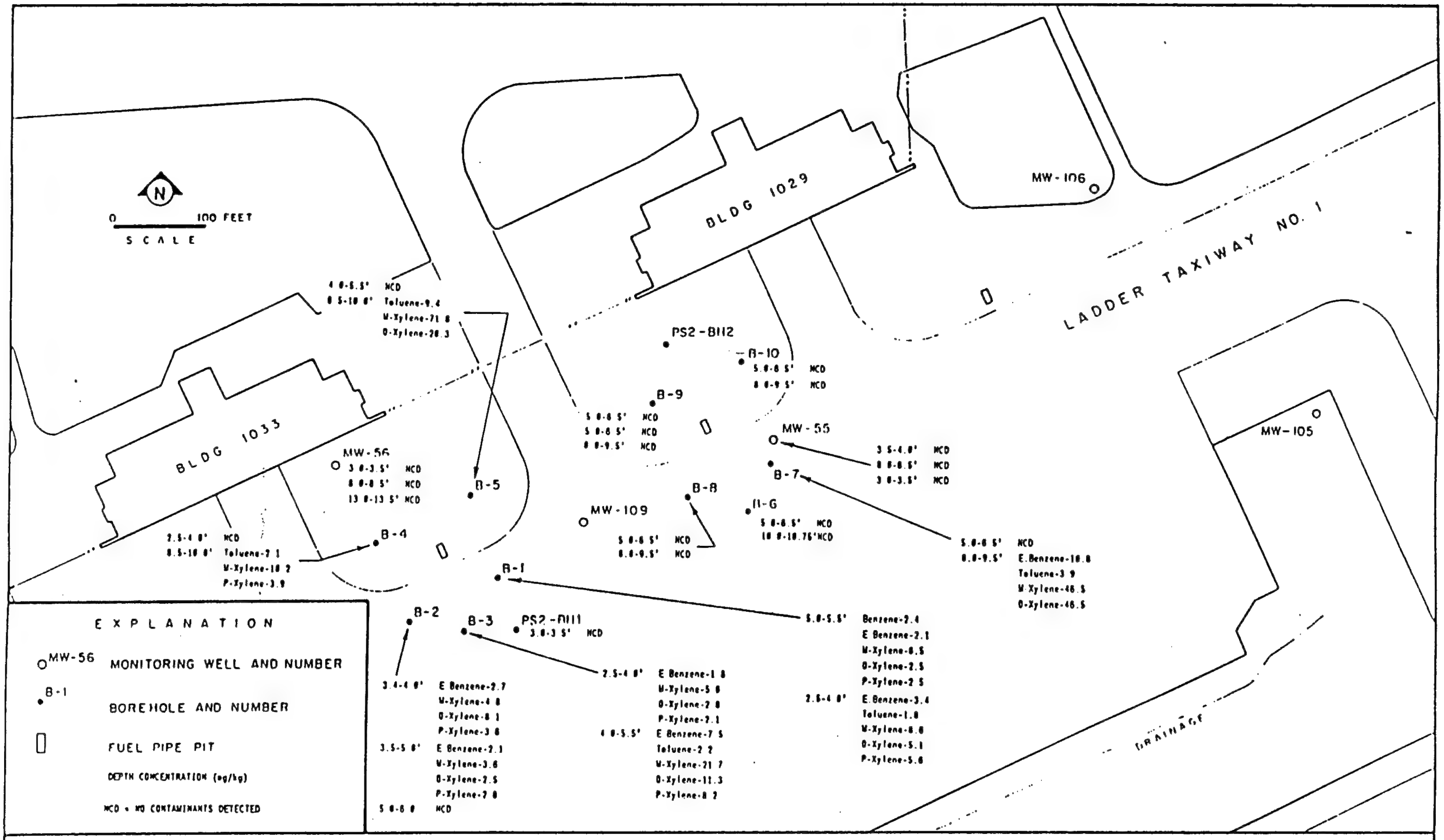



Figure 4-17. Site OU-1 (PS-2) Historical Analytical Results for Soils - VOCs

Source: SAIC, 1990

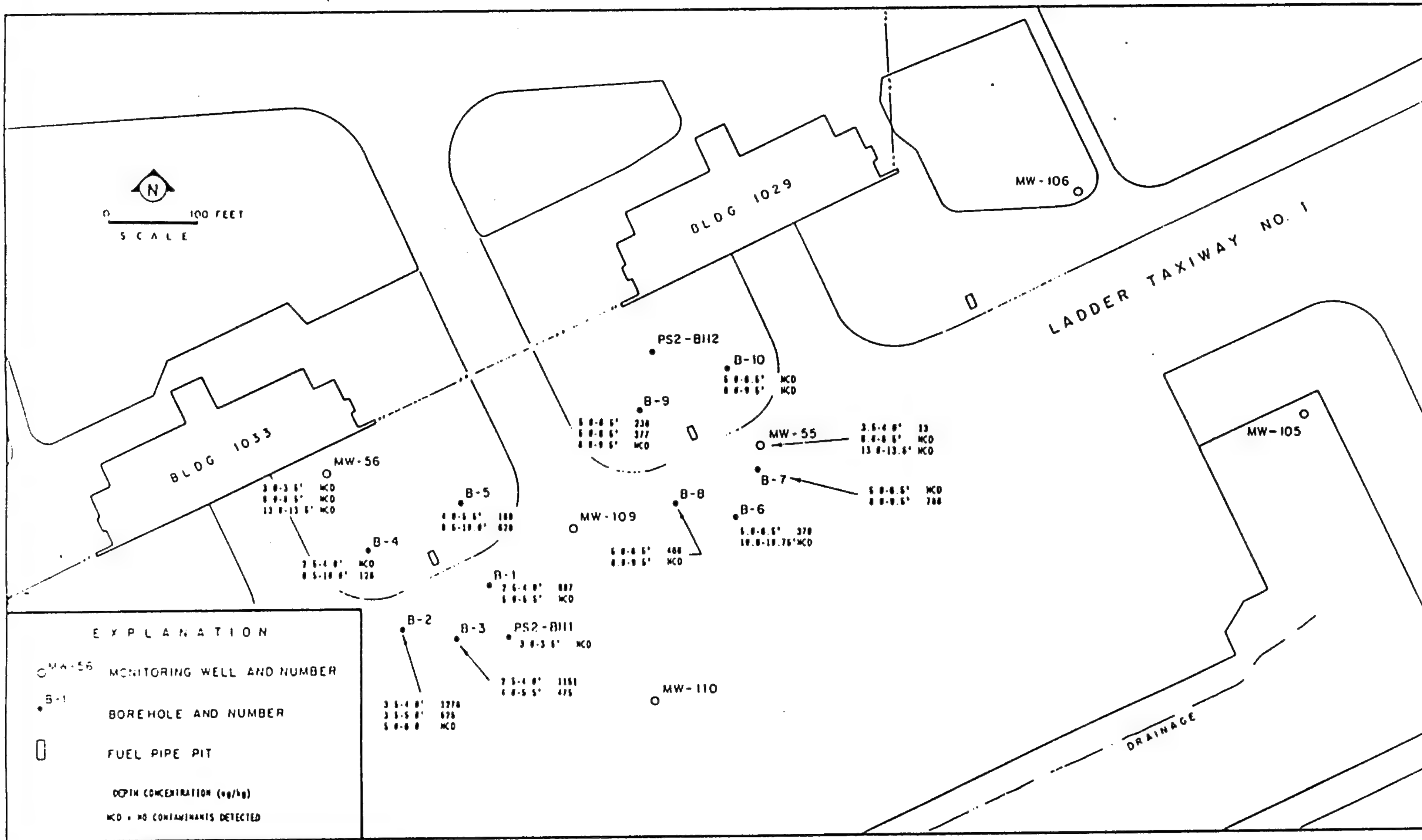



Figure 4-15. Site OU-1 (PS-2) Historical Analytical Results for Soils - TPH

Source: SAIC, 1990

TABLE 4-10

CONTAMINANT OCCURRENCE AND DISTRIBUTION - SOIL BORING SAMPLES
TPH AND BTEX RESULTS (mg/kg)
ROUND 11
SITE PS-2
FAIRCHILD AFB, WASHINGTON

| Parameter | Soil Boring | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| **0- TO 2-FOOT INTERVAL** | | | | | | | | | | |
| Benzene | 0.003U(1)(3) | | 0.003U | | 0.003U | | | | 0.003U | |
| Toluene | 0.003U | | 0.003U | | 0.003U | | | | 0.003U | |
| Xylene | 0.003U | | 0.003U | | 0.003U | | | | 0.003U | |
| Ethylbenzene | 0.003U | | 0.003U | | 0.003U | | | | 0.003U | |
| TPH | <20(2) | | | | <20 | | | | <20 | |
| **2- TO 6-FOOT INTERVAL** | | | | | | | | | | |
| Benzene | | 0.003U | 0.004U/ 0.004U | | 0.004U | 0.006 | | 0.004U | 0.004U | 0.003U |
| Toluene | | 0.003U | 0.004U/ 0.004U | | 0.004U | 0.004U | | 0.004U | 0.004U | 0.003U |
| Xylene | | 0.007 | 0.004U/ 0.004U | | 0.004U | 0.004U | | 0.004U | 0.004U | 0.003U |
| Ethylbenzene | | 0.003U | 0.004U/ 0.004U | | 0.004U | 0.005 | | 0.004U | 0.004U | 0.003U |
| TPH | | <20 | <20/<20 | | 180 | <20 | | <20 | <20 | <20 |
| **6- TO 10-FOOT INTERVAL** | | | | | | | | | | |
| Benzene | | 0.005U | | | | 0.460U | | | | |
| Toluene | | 0.005U | | | | 0.460U | | | | |
| Xylene | | 0.014 | | | | 4.7 | | | | |
| Ethylbenzene | | 0.005U | | | | 1.7 | | | | |
| TPH | | <20 | | | | <20 | | | | |

Source: HNUS, 1993

TABLE 4-10
CONTAMINANT OCCURRENCE AND DISTRIBUTION - SOIL BORING SAMPLES
TPH AND BTEX RESULTS (mg/kg)
ROUND 11
SITE PS-2
FAIRCHILD AFB, WASHINGTON
PAGE TWO

| Parameter | Soil Boring | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
| COMPOSITE | | | | | | | | | | |
| Benzene | | | | 0.004U | | | 0.420U | | | |
| Toluene | | | | 0.004U | | | 0.420U | | | |
| Xylene | | | | 0.004U | | | 0.420U | | | |
| Ethylbenzene | | | | 0.004U | | | 0.420U | | | |
| TPH | | | | <20 | | | 1,200 | | | |

(1) U signifies a nondetected result or a detection limit result.
(2) < signifies a nondetected result.
(3)
- 2-Hexanone was also detected in soil sample PS2-SS-001-001 at 0.007 mg/kg.
- Methylene chloride was detected in several subsurface soil samples (PS2-SS-002-002, PS2-SS-003-001,PS2-SS-003-002, PS2SS008-001, PS2SS009-001, and PS2SS009-002) at a concentration range of 0.011 to 0.110 mg/kg.
- Acetone was detected in PS2-SS-006-002 at 1.7 J mg/kg.
- Acetone was detected in PS2SS007-001 at 1.2 J mg/kg.

Source: HNUS, 1993

Table 3.1
INITIAL CONDITIONS
PS-2
Fairchild AFB, Washington

| | SOIL GAS | | | | SOIL | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Well No.- depth | $O_2$ (%) | $CO_2$ (%) | TVH-jf (ppmv) | TVH (ppmv) | TRPH (mg/kg) | Benzene (mg/kg) | Toluene (mg/kg) | Ethylbenzene (mg/kg) | Total Xylenes (mg/kg) | Temp. (°F) |
| VW1-(5-10) | 1.0 | 7.9 | 110,000 | >10,000 | 250 | 0.7 | 0.5 | 7.2 | 47 | |
| VMP1-4 | 2.5 | 4.8 | 78,000 | >10,000 | 280 | 4.1 | ND | 21 | 120 | 62.8 |
| VMP1-7.5 | 0.5 | 4.8 | | >10,000 | | | | | | 63.3 |
| VMP2-4 | 3.0 | 0.5 | | >10,000 | 980 | 0.14 | ND | 0.71 | 3.8 | |
| VMP2-6.5 | 0.5 | 5.2 | | >10,000 | | | | | | |
| VMP3-4 | 2.0 | 6.5 | | >10,000 | | | | | | |
| VMP3-7 | 0.3 | 9.7 | 170,000 | >10,000 | | | | | | |

*LEGEND*

TRPH : Total Recoverable Petroleum Hydrocarbons (EPA 418.1)
TVH-jf : Total Volatile Hydrocarbons as jet fuel (EPA TO-3)
TVH : Total Volatile Hydrocarbons (THVA field instrument)
ND : not detected
mg/kg : milligrams per kilogram
ppmv : parts per million by volume

*NOTES*

1. $O_2$/$CO_2$ measurements by field instrumentation.
2. Soil sample at VW-1 taken at a depth of 7.5 feet bgs.
3. Benzene, Toluene, Ethylbenzene, and Total xylenes by EPA Method 8020.

04/10/94
ps2.xls

**Source: ES, 1994**

# TABLE 2.1
# SOIL and SOIL GAS ANALYTICAL RESULTS
# PS-2
# Fairchild AFB, Washington

| ANALYTE | METHOD | UNITS | SAMPLE LOCATION - DEPTH (WELL NUMBER AND FEET BELOW GROUND SURFACE) | | |
|---|---|---|---|---|---|
| **Soil Hydrocarbons:** | | | VW1-7.5 | VMP1-4 | VMP2-5 [1] |
| TRPH | EPA 418.1 | (mg/kg) | 250 | 280 | 980 |
| Benzene | SW8020 | (mg/kg) | 0.7 | 4.1 | 0.14 |
| Toluene | SW8020 | (mg/kg) | 0.5 | <0.49 | <0.051 |
| Ethylbenzene | SW8020 | (mg/kg) | 7.2 | 21 | 0.71 |
| Xylenes, Total | SW8020 | (mg/kg) | 47 | 120 | 3.8 |
| **Soil Inorganics:** | | | VW1-7.5 | VMP1-4 | VMP2-5 [1] |
| Iron | SW7380 | (mg/kg dry wt.) | 23,500 | 26,100 | 18,000 |
| Total Alkalinity | SM403 | (mg/kg as $CaCO_3$) | 580 | 360 | 74 |
| pH | SW9045 | (units) | 7.6 | 8.1 | 7 |
| TKN | E351.2 | (mg/kg dry wt.) | 610 | 190 | 130 |
| Total Phosphorus | E365.2 | (mg/kg dry wt.) | 80 | 170 | 92 |
| **Soil Physical Parameters:** | | | VW1-7.5 | VMP1-4 | VMP2-5 [1] |
| Moisture Content | ASTM D2216 | (% by wt.) | 15 | 5.5 | 9.3 |
| Gravel | ASTM D422 | (% by wt.) | 4.7 | 22.9 | 1.0 |
| Sand | ASTM D422 | (% by wt.) | 46.6 | 54.1 | 64.9 |
| Silt | ASTM D422 | (% by wt.) | 39.9 | 14.7 | 27.0 |
| Clay | ASTM D422 | (% by wt.) | 8.9 | 8.2 | 7.2 |
| **Soil Gas Hydrocarbons:** | | | VW1 | VMP1-4 | VMP3-7 |
| TVH-jf | EPA TO-3 | (ppmv) | 110,000 | 78,000 | 170,000 |
| Benzene | EPA TO-3 | (ppmv) | 150 | 160 | 400 |
| Toluene | EPA TO-3 | (ppmv) | <3.7 | <2.3 | 93 |
| Ethylbenzene | EPA TO-3 | (ppmv) | 24 | 31 | 42 |
| Xylenes, Total | EPA TO-3 | (ppmv) | 130 | 130 | 190 |

**NOTES:**
TRPH - Total recoverable petroleum hydrocarbons
TVH-jf - Total volatile hydrocarbons as jet fuel
TKN - Total Kjeldahl nitrogen
ppmv - Parts per million by volume
[1] - Sample labelled as VMP2-4, but collected at 5 ft bgs

$CaCO_3$ - Calcium carbonate
mg/kg - milligrams per kilogram
NA - Not Analyzed

06/20/94
ps2.xls

Source: ES, 1994

## TABLE 4-3. SUMMARY OF PURGEABLE AROMATIC VOLATILE ORGANICS (SW5030/SW8020) AND PETROLEUM HYDROCARBONS (WTPH-D) LABORATORY ANALYSIS FOR SOIL SAMPLES COLLECTED AT PS-2 WELL BORINGS MW-229 AND MW-230 IN NOVEMBER 1994

| PARAMETERS | PRACTICAL QUANTITATION LIMIT | | ENVIRONMENTAL SAMPLE | | | | FIELD BLANKS | | METHOD BLANKS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | PS02229S01 | PS02229S02 | PS02230S03 | PS02531S04[1] | PS02229E05[2] | PS02FQCT06[3] | 22NOV94-A0 | 23NOV94-A1 | 23NOV94-A1X |
| | SOIL | (WATER) | 108692-0003-SA | 108692-0004-SA | 108692-0005-SA | 108692-0006-SA | 108692-0002-EB | 108692-0001-TB | 108692 | 108692 | 108692 |
| LABORATORY ANALYSIS[4] | | | | | | | | | | | |
| Depth of Sample (feet) | NA | | 5.5-6.0 | 8.0-9.0 | 7.0-8.0 | 7.0-8.0 | NA | NA | NA | NA | NA |
| Percent Moisture (%) | NA | | 11.2 | 13.2 | 7.9 | 7.8 | NA | NA | NA | NA | NA |
| Benzene | 0.0050 mg/kg | (0.50 µg/L) | 0.0050 U mg/kg | 0.25 U mg/kg | 0.0050 U mg/kg | 0.0050 U mg/kg | 1.0 U µg/L | 0.50 U µg/L | 0.50 U µg/L | 0.0050 U mg/kg | 0.25 U mg/kg |
| Toluene | 0.0050 mg/kg | (1.0 µg/L) | 0.0050 U mg/kg | 0.25 U mg/kg | 0.0050 U mg/kg | 0.0050 U mg/kg | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 0.0050 U mg/kg | 0.25 U mg/kg |
| Ethylbenzene | 0.0050 mg/kg | (1.0 µg/L) | 0.0050 U mg/kg | 0.25 U mg/kg | 0.0050 U mg/kg | 0.0050 U mg/kg | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 0.0050 U mg/kg | 0.25 U mg/kg |
| Xylenes, Total | 0.0050 mg/kg | (1.0 µg/L) | 0.0050 U mg/kg | 0.25 U mg/kg | 0.0050 U mg/kg | 0.0050 U mg/kg | 1.0 U µg/L | 1.0 U µg/L | 1.0 U µg/L | 0.0050 U mg/kg | 0.25 U mg/kg |
| Surrogate Bromofluorobenzene | 30-137% | (29-137%) | 74% | 102% | 98% | 78% | 105% | 103% | NA | NA | NA |
| Diesel Fuel #2 | 0.50 mg/kg | (0.50 mg/L) | 28 U mg/kg | 29 U mg/kg | 27 U mg/kg | 27 U mg/kg | 0.50 U mg/L | NA | NA | NA | NA |
| Jet Fuel | 0.50 mg/kg | (0.50 mg/L) | 28 U mg/kg | 29 U mg/kg | 27 U mg/kg | 27 U mg/kg | 0.50 U mg/L | NA | NA | NA | NA |
| Unknown Hydrocarbon | 0.50 mg/kg | (0.50 mg/L) | 28 U mg/kg | 850 mg/kg y | 800 mg/kg y | 27 U mg/kg | 0.50 U mg/L | NA | NA | NA | NA |
| Surrogate o-Terphenyl | 75-125% | (75-125%) | 81% | 104% | 118% | 113% | 102% | NA | NA | NA | NA |

1 PS02531S04 is a field duplicate of PS0230S03.
2 PS02229E05 is an equipment blank.
3 PS02FQCT06 is a trip blank.
4 Laboratory analytical results are presented in Appendix A.

U = Not Detected. Value listed is the detection limit.
NA = Not Analyzed or not applicable.
y = Chromatographic profile is not consistent with pattern(s) exhibited by reference fuel standards. Quantitation of unknown hydrocarbons in sample is based on diesel fuel

Source: ICF, 1995

# APPENDIX B - 1e

## ADDITIONAL SITE MAPS INCLUDING:

## BEDROCK TOPOGRAPHY & STORM SEWER LINES

Source: HNUS, 1993

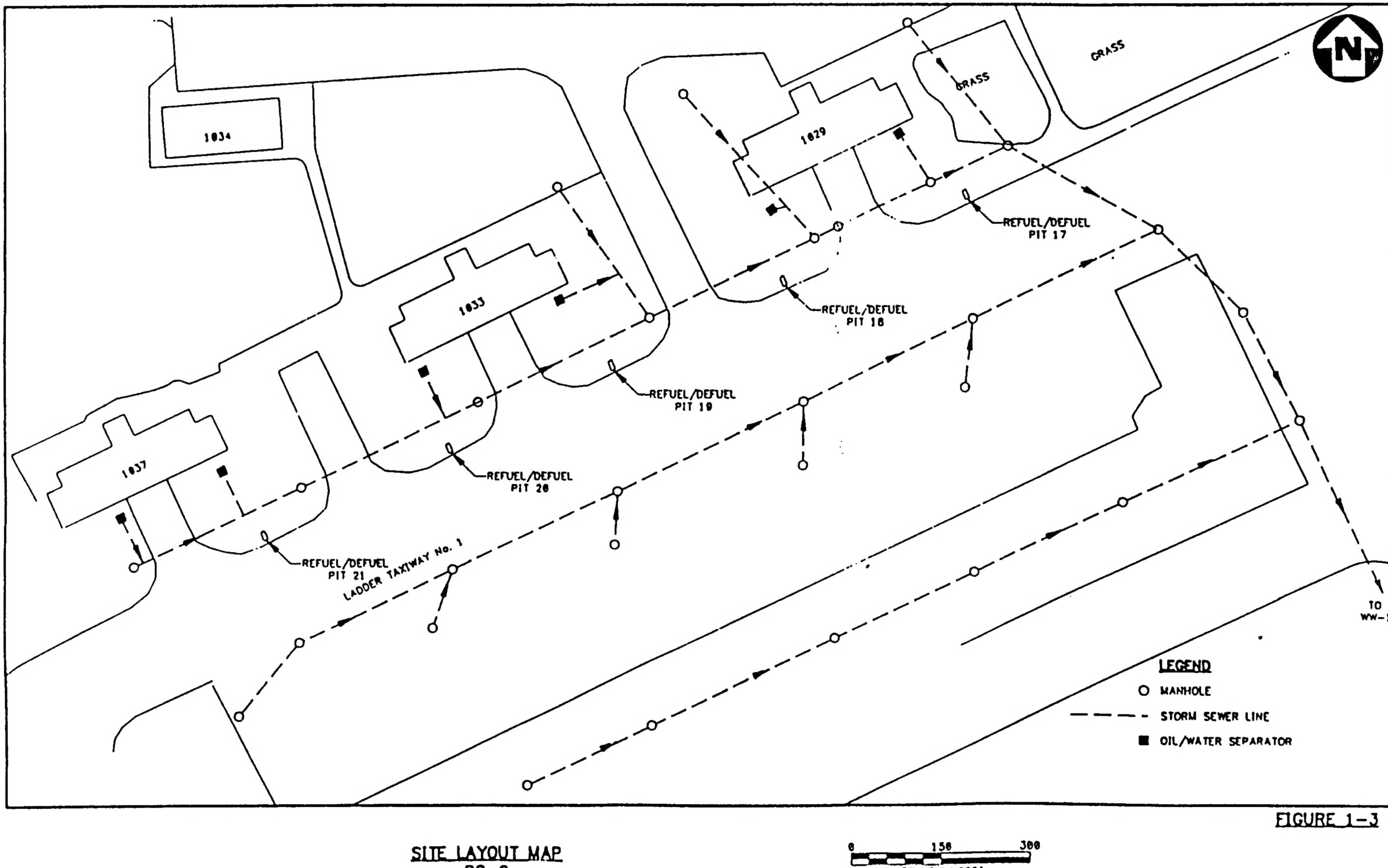
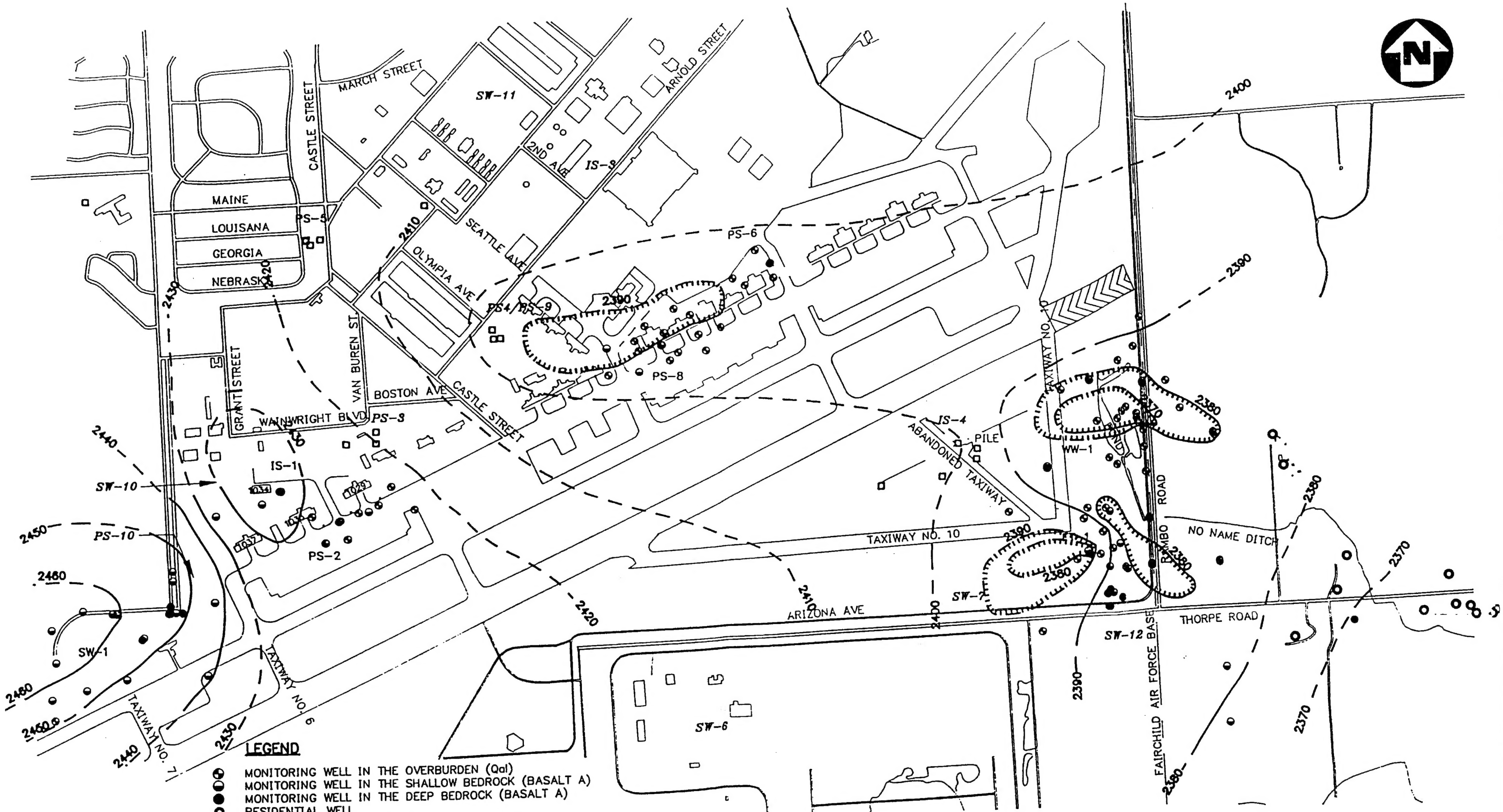



FIGURE 1-3

SITE LAYOUT MAP
PS-2
FAIRCHILD AIR FORCE BASE, WASHINGTON




## LEGEND

- MONITORING WELL IN THE OVERBURDEN (Qal)
- MONITORING WELL IN THE SHALLOW BEDROCK (BASALT A)
- MONITORING WELL IN THE DEEP BEDROCK (BASALT A)
- RESIDENTIAL WELL
- WELL LOCATED OUT OF STUDY AREA (P2 SITE)
- SW-1 PRIORITY 1 SITE
- *PS-3* PRIORITY 2 SITE – SELECTED P2 SITES AND MONITORING WELLS SHOWN IN ITALICS
- 2460 STRUCTURE CONTOUR – SOLID WHERE KNOWN, DASHED WHERE INFERRED OR COMPILED FROM SAIC (1990c). ELEVATION IN FEET AMSL
- ENCLOSED DEPRESSION

BEDROCK CONTOUR MAP
TOP OF BASALT A
PRIORITY-1 SITES
FAIRCHILD AIR FORCE BASE, WASHINGTON

0 1000 2000
SCALE IN FEET

FIGURE ES-2

Source: HNUS, 1993